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A

TREATISE

U P O N

COAL-MINES:

O R,

An A T T E M P T to explain
Their general MARKS of Indication,
Acknowledg'd and probable.

T O G E T H E R W I T H .

Particular Instances of their public Utility;
Objections to the Mode of their Discovery, and to their
Manufacture, obviated, &c.



L O N D O N ;

Printed for the AUTHOR; and sold by F. NEWBERRY in
St. Paul's Church-Yard. MDCCCLXIX.

A
T R E A T I S E

COAL-MINES:

AN ATTEMPT TO EXAMINE

Their General

Advantages



TOGETHER WITH

Particular Instances of their public Utility;

Objections to the Abuse of their Privileges; and to their

Manufactures, &c.



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St. Paul's Church-Yard, Manchester.



INTRODUCTION.

A Good cause, they say, wants no defence — it cannot indeed as far as the integrity of it is concerned; but this single support will not always recommend it to encouragement and patronage; thousands are convinced of the integrity, benevolence, and usefulness of a design, which yet they venture not to espouse, being not convinced of its feasibility. This circumstance is by far the most material, nay the one thing needful, in every scheme of public utility, and, in the case before us, requires nothing more than explication and illustration to recommend it to regard — Like the jewel just drawn out of the mine, its intrinsic worth and weight is admitted by all, who will yet think it more worthy their purchase, when executed with a brilliant polish, and set in a bright and lively exposition. This is presumed to be much wanted in the point which the Author has in view, and it is to be feared will be found wanting but too much in the course of the ensuing enquiry; it is naturally a dark subject, and, concealed as it is, it has yet been more obscured by misrepresenta-

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tion and prejudice: Till these therefore are brought to light and cleared up, till men are divested of prepossessions, their misconceptions rectified, and all the rubbish of objection removed, it will be impossible to search undisturbed for truth — not to say, that it lies ever at the bottom, and requires not only the skill of a director to point out the way, but great pains and assiduity in the searcher to bring it to light; who must force his passage, penetrate every impediment, and dig deep to find it.

Agreeably then, before we enter upon the most interesting topic, the probable marks of a Coal-Mine in places where such has not yet been found, (which is nearly the same with the feasibility of finding them) it will be consistent with the plan of this design

To evacuate all general objections;

And in order to engage the Reader's attention yet the more to the notice of the former, and to weaken his attachments (if such he has) to the force of the latter, it will probably be worth while to introduce the whole with

C H A P.



C H A P. I.

A Description of the eminent Advantages and public Utility of COAL - MINES.

THE first and most obvious advantage of coals cheap is in the article of common fires; but this instance of *general* advantage is attended with very *particular* conveniencies (all exclusive of the general comforts of a warm house) which are either not duly known, or however little regarded by Gentlemen, &c. who can afford themselves a good fire at a great price, viz.

§ 1. Among the poor it is, *generally*, the employment of one person in a family in the winter season for three hours more or less every day to seek fire-wood,* in quest of which they oftentimes get themselves very wet in their feet and legs, (of which inconvenience more hereafter, page 11.) and lose all that time from their proper

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work;

* This it is obvious can happen only in those parts, where there is much growth of wood; at least growth enough for such a purpose: and this very probably is in most parts of England, where there are no Coal-Mines.

work; and, what does sometimes steal them farther from their work, some part of the evening is often employed in patching up the cloaths they have rent in their passage over hedges, ditches, brakes, &c. These articles, viz. the loss of time, and the being exposed to wet and cold, may seem frivolous to many who have never attended to them, and who perhaps regard them as no other than casual inconveniencies, of which the sufferer is rendered insensible by habit, and these very persons insensible of it by the sufferer's acquiescence. — No, but the importance of it is to be concluded from its universality, in which case, as in a thousand others, the *maxima* of weight and significance arise *ex minimis* — A small rate of taxation affecting every family in a kingdom amounts to a prodigious sum. In most of the western, southern, and many of the central parts of England, (and other parts of the world likewise in the same condition) this inconvenience does assuredly take place: but how much of this time might be saved, how much more work of public use accomplished, by this one person in the space of a twelve-month, (for some fuel must be provided in summer as well as winter) were coals at the price supposed in the note *. At this rate, if the earnings

* In every place whatsoever where there are Coal-Mines, they may fairly be presumed to be sold at no higher price than five-pence a bushel for four or five miles round; and in a great many places they are sold at that distance from the mine for less.

ings of this person spinning, or other staple employment, be put at a groat a day, then a quarter of this day's work saved from the necessity of this random search would procure almost the value of a peck of coals; which in a close room, (see page 18.) and frugally husbanded, would be for the most part equivalent in point of use to their scrapings and gatherings abroad, save the searcher from wet and cold, and extraordinary wear of cloaths, and make a suitable addition to the stock of some public manufacture. Probably in most places within the precincts of a mine above-mentioned, the real price of coal may be less than the price here supposed, and so the difference may favour the above calculation.

By the way; this single inconveniency in every part of it cannot be adequately apprehended, except by personal observers, who are in all cases whatever the most competent judges of the state and difficulties of the poor, that is, not only of those who receive the alms of their parish, but of those who do not; of which latter many may be found as capable of relief, and more worthy of it, than the former; and from their better regards of decency and appearance are often hastily concluded to be free from indigence, by persons who never stoop into their humble cell to take a personal notice of their necessities; and who often run into misapprehensions of their temper and conduct by
not

not knowing the particular state and exigencies of their condition.

§ 2. Another inconvenience, resulting immediately from the last mentioned, is the demolition of hedges, lopping of trees, carrying away the fences of stack-yards, &c. &c. cafes, in which every accessible retirement, corner, and other place of concealment is ransacked for fuel. The mischiefs ensuing upon such indiscriminate pillage are very sensibly felt and acknowledged by every farmer; and this to the Author's personal notice in several counties in which he has lived. Now remove from the poor this necessity, and the advantages of this removal will be proportionable. It is farther worth notice, that this practice is so common, and so much defended by necessity, that it has changed its very name among the persons concerned, who tell you, That they do not *steal* firing, but *take it*; that there is no harm in lopping a pollard tree; that they claim a right to firewood in the fields which is out of use and done with. Thus they have entirely disunited the idea of theft from that of rapine, and so powerful is the plea of pinching cold, that of all these distressed ravagers *Unde habeas quærit nemo, sed oportet habere.*

§ 3. Another inconvenience, or rather misery, in the dearth of firing, consists in the multitude of persons afflicted with agues; (the disparity in the
number

number of such between Dorset and the parts about Durham being, by general computation, as eight to one, and in some particular situations of the latter, being a great deal more) labourers are obliged to endure wet and cold in a very great variety of their work, and when they come home at night, poor victuals and a cool chimney corner is their general fare; they have neither time nor fire enough to dry their stockings, cloaths, &c. before the next morning, when they put them on again damp as they are; and the repetition of this hardship chills their blood, and throws them into agues. This is a common misfortune with all out-door labourers, and might be, if not absolutely remedied, yet in a great degree alleviated by a small and constant coal fire in a close room, such as even poor families usually enjoy in places where coals are cheap. Not only indeed out-door labourers, but the women and children who are usually employed within, suffer the same distemper in numerous instances from the severe, because unremitting, constancy of winter's cold, and are equally helpless in the articles of both inward remedy and outward warmth. The inhabitants of those parts of the north, and other places, where coals are plentiful and very cheap, have not a just apprehension of the advantages which in these respects they possess, because they know not what it is to live in a contrary condition: and the plenty of their subsistence, and the warmth of their houses is an ample, though undiscerned, compensation

fation for the nakedness of numbers of poor children which is still observable in several of these parts. For the same reason it is not possible for any man to form a competent judgement of the advantages of having firing plentiful and cheap, who has not known the contrary extreme in another situation.—Nothing either in naturals or morals is more illustrative of an object than the notice of its contrast. — Tell a man who is even in easy circumstances of life, and buys coals at the pit-heap for two-pence halfpenny or three-pence a bushel, That you live comfortably upon a small income, where coals are thirteen-pence a bushel, wood for firing very dear, and the consumption of it every year greatly exceeding its produce, such a man at first thought will have no other idea of the inconveniencies of this than in the want of a constant warm fire-side; and without any farther reflection upon its difficulties will urge the necessity of your œconomy, hardiness, and patience: — but even with no more thought of its inconvenience than this, while he admires your submission, will abhor your situation.

By way of confectary to this last article it may be worth while to observe, that all animal bodies require, in order to their preservation, a suitable balance of heat and cold, just as all the parts of nature depend upon some proper degree of equilibrium (the sense of an extreme) in the qualities of drought and moisture, light or dense, hot or cold air.

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When any of these particular qualities on either side preponderate, the animal creation is sure to receive an uneasy account of it, and becomes in due proportion exposed to disorder — it catches distemper from a too moist or thin, or cold air, long drought, much heat, &c. meteorous singularities in the temperament of the air, which sleeping and waking they breathe. But the frame of the human species seems exposed to singular inconveniencies from cold and heat, any short extreme of heat, or any uncommon continuance of cold endangering the health of the subject: therefore the equilibrium between these two affections in the human sensation is highly expedient, and it is thence very obvious to conceive, that where this equilibrium is disturbed by the powers of nature, the power of art is necessary to counteract this anomaly, and restore the balance.

§ 4. Another inconvenience consists in a practice common among day-labourers, mechanics, &c. viz. of spending in the winter evenings part of the profits of their work in a public-house for the sake of a warm fire-side; the opportunity of which accommodation at their own houses would engage numbers of these persons at home, and save their money. But in this article the accommodation of a warm chimney corner is only the first temptation; when they are got here, another temptation occurs, *i.e.* the conversation of the company, who entertain each other with merry jokes, gibes, songs, smutt,

smutt, &c. so the old *five reasons why a man should drink* operates with great efficacy here: This, with the warmth of their situation, disperses all their gloom, opens their hearts, and makes them generous even against their inclinations, — t'other pot, and t'other mug is repeated oftener than at first designed, and the reckoning paid (if then paid) with a reluctance visible to the whole company. This is a practice well known in many parts of the country where firing is very dear, and as these temptations, in both cases, are very natural, it were no presumption to suppose them general. Remove then the occasion by suitable accommodations at home, how many shirts, stockings, &c. might not be saved in the space of a year to a half naked family from this single instance of frugality!

To these articles of domestic conveniency in the plenty of coals might be added, the ease and cheapness of dressing victuals where a constant coal fire is kept; the expence of doing which where fuel is very dear, is in many cases equal to the victuals itself, especially if provisions are cheap: The prevention of frauds in the measure or quality of coals brought by a retailer at a great distance: The small attendance and attention to a coal-fire in comparison of what is necessary to a fire of wood:* No doubt other conveniencies will

* Here wood is supposed to be the *general* provision for firing, and it may reasonably be so, considering the few places or parts, comparatively speaking, which supply plenty of other materials, as of peat, turf, stubble, flax-peelings, &c.

will occur to the reader in the course of his observation or reflection, who it is hoped will not deem what is here said to be superfluous, as if it were already well known — 'tis true, the matter of these observations may be known and acknowledged, as a thousand things are besides, which yet are not well attended to or considered in all their consequences; and admitting that they were so, yet in a treatise written professedly upon the subject, it may be very expedient to draw out these advantages to open view for the sake of easy and clear conviction — clear description gives fresh beauty to the day, though the lustre of it be all the while felt and acknowledged; and a lively representation even of the brightness of the sun often renders it little less enchanting in idea, than 'tis comfortable in reality.

CHAP.

C H A P. II.

General Utility of Coals in Manufactures.

ANOTHER capital article of advantage attending the cheapness and plenty of coals consists in the business of manufactures, ex. gr.

§ 1. Brick and tile, the principal expence of which consists in the burning, and one particular excellence of each in being well burnt. Where fuel for this purpose is dear, the manufacturer is always tempted to be frugal in fire, and is actually so oftentimes to such a degree, as to lose a part of, or a whole burning of brick, which soon after upon the accession of moist air begins to shiver to pieces, and is incapable of any use; and where it is not so imperfectly burnt, but that it remains capable of some use, in this case it is seldom of long duration: But where fuel is cheap, the manufacturer would not be tempted to expose his goods to so much injury. The truth of this whole observation is evident in every part of England according to their respective plenty of fuel for burning these materials; every one knows it. There is undoubtedly very good clay in most parts of England within an easy reach of carriage for the purposes of both building and roofing, and were fuel for burning in any tolerable proportion, what advantages would not thence accrue to walls, partitions,

titions, pavements, &c. At St. Ives, Huntingdonshire, their best brick is of a yellowish hue, and remarkably firm; and some of their streets or cause-ways are paved with it; they burn it with some kind of peat, which luckily they have in much plenty: otherwise they might probably be often in the same predicament with Exeter, where their chief firing is wood and imported coal; the latter exceeding dear, and the other not cheap. At Stoke-hill, in that neighbourhood, a large pile of bricks, some years ago, design'd for a new building, made of good clay, lay mouldering into rubbish from the want of sufficient firing when they were burnt.

En passant, let us take notice, that the difference in the several kinds of clay for the purpose of making brick and tile, is not such as can affect the argument here; because in most places, such kind of clay may be met with well work'd, as being cleansed and burnt, will be worth the trouble, and afford a very good material for common building.

§ 2. In the single article of lime, the advantage of cheap firing is very remarkable, and almost surprising. Where the houses are cemented with common mortar, the walls are not, nor can be, nearly so durable as with pure lime, or a due proportion of it; they fall apart generally

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one side from another, and do not break, but split in two; and as they open thus by degrees, and become hollow, the cold and wind enters through a great many chinks and holes, the wall bulges and shrinks by degrees, till one side, from the want of good cement, finally falls off from the other*. Where lime is cheap, the cottages are all more close and warm, than where it is dear; the ceilings and plaistering better.---- Such are the cots, even the single rooms, of labourers in many parts of the north of England; and a room thus close and compact, with a constant coal-fire, would go far to prevent, certainly would suspend the inconveniencies referred to at page 11. This is the reason why the cottages in the north of England, and indeed the buildings in general, are much better both in point of room and firmness, than those in the west; for where coals are cheap, and lime-stone in great plenty, it follows of course, that both the buildings must be better, the roofs closer, and house-rent lower, than in places where these conveniencies are scarce or dear; and it is confirmed by fact, in respective comparisons of abundance of places.--- The parts about Durham, Sunderland, and Newcastle, are extremely populous, as they are extremely well provided with fish and coals; and of

* Cottages in general are meant here, not gentlemen's houses, which are generally well executed, though at an extraordinary expence.

of one certain genteel village in those parts, it has been well remarked, that building is cheaper there, than in any one part of England besides.

§ 3. Eminent advantages appear likewise in the case of all other manufactures, wherein fire is employ'd, and in proportion as it is so. The manufactures of iron, cloth, &c. cannot be executed without plenty of this useful article, and are observed to flourish most, *cæteris paribus*, where it is cheapest. Why has land-trade of late years made so great a progress northward, and arrived to a pitch of improvement there, unforeseen to the most discerning of our forefathers? principally, on account of the plenty of firing, where the general subsistencies of life, meat, clothes, and fire, are for the most part more accessible to the poor than in other places; even the former two are greatly supported by the use and benefit of the latter. For where one necessary of life is wanted, in order to prepare or work another, if the former be cheap, the latter must assuredly be so in proportion. Thus it is with respect to firing in the instance of single occupations, and common handicrafts, as bakers, brewers, maltsters, public-houses, hatters, &c. &c. all of whom, as well as the public manufacturer, must be much more sensible of positive convenience in the possession, or of inconveniency in the want, of this material advantage, than any description of either can make them.

C H A P. III.

Errors in the Mode of Discovery confuted.

§ I. **I**N a discovery so beneficial to the world as that of coal-mines, in places wherein none such have yet been discovered, it is not to be imagined that any objections will arise from the fatal accidents of fire; the introducing an additional number of poor employ'd in working these mines, the great consumption of timber in fabricating the works, &c.

These inconveniencies (admitting that they always actually took place) are but accidental to such an employment, and a very slender consequence of such a discovery. Time and care might prevent, or greatly abate the power of these casual inconveniencies; the solid advantages of the discovery itself, would far outweigh these, and extremely supersede all the objections which can be grounded upon them. It is but weakness and futility to urge any casual inconvenience against any public and avowed general advantage; such objections have no more force than the existence of superstition and enthusiasm, when form'd into an objection against religion; of frauds and cozenage, when against an established commerce; of faction and party, when against a well poiz'd political

litical constitution ; or, of the barren parts of nature, when against a beautiful and fruitful world.

§ 2. There are also other objections, which are directed in discouragement to any attempts of the discovery above-mentioned ; but they are such as would never be urged, did the abettors of them duly consider the connexion they have with the subject of this enquiry ; that is, the investigation of coal-mines.

One of these objections is the phenomenon of the gravitating rod or branch ; which, say they, is of such a property, that, while carried along to and fro in a direction parallel to the horizon, if, during this gestation, the bearer happens to pass over the edge or extremity of some coal-mine in the earth directly beneath him, the rod will that moment be observed to bend downwards, as if attracted by the mine below it. This phenomenon of the rod, they tell you, is indicative of a coal-mine below, and it is therefore called, the *virgula divinatoria*, Aaron's rod, &c. Now rods, or young branches of hazle, have been made use of by gentlemen for this purpose, who finding these rods not to have gravitated at all in such places as they have made trial upon, conclude at once that no coal-mine is there.

Supposing then the rod to have this *automatous* tendency ; a *non causâ pro causâ* is a com-

mon scholastic fallacy; and that is the very case here. For this downward bending of the rod cannot be affected by any attraction of gravitation whatever from a coal-mine below, were the mine twice, thrice, manifold, thicker than it is found to be. It is contrary indeed to the most established rules of sound philosophy, to all the laws of nature; and therefore the objection itself (occurring from the rod continuing in an even and straight posture in the hand of the bearer) is fallacious, and the very supposition of its tendency to the mine by physical attraction false.

It may, however, be very proper to discuss this objection more at large, for the sake of gentlemen who are well known to have adopted it, and, being persons of sense and discernment in other respects, have a right to know the sentiments of any man who undertakes a subject connected with their apparent mistakes. All men have prejudices, both authors and readers; and if the former of these should be fortunate enough to annihilate those of the latter, it will be some kind of atonement to the world for the depravity or pertinacity of their own.

No effect is without its cause, which cause must of course be adequate to both the nature and the degree of that effect. Now the *general*
tendency

tendency of this rod to the earth, as of all other bodies, is caused by the attraction or gravitating influence of the whole earth ; but if this rod has an extraordinary tendency downwards, in some *particular* places more than in others, this extraordinary effect must proceed from some extraordinary cause, which operates stronger in these particular places where the phenomenon appears ; and this extraordinary cause is supposed by the objection, to be a coal-mine directly below it. Now the thickest known strata of coal in England, which are fathomable, are not more than eight or nine feet thick ; and what a nothing is any force of attraction in this body, supposed to give the extraordinary, in comparison of the whole diameter of the earth, which actually gives the ordinary tendency of this rod to the surface ! The difference in the supposed cause, is so infinitely minute, that it becomes a meer non-entity in the estimation. For, the power of this extraordinary cause, is supposed to preponderate in the effect beyond the ordinary gravitation of the whole earth ; therefore the existence of the cause must be in bulk or power, or both, proportionable : but this the mine could not possibly be, were it as hard and heavy as solid marble, and even as thick as the depth of any discoverable mine from the surface ; it bears no proportion to the earth's diameter, which is near eight thousand miles—not

so much as half a pound weight bears to the momentum of a large ship of burden.

Philosophically, therefore, any man would be inclined to suspect the very truth of this phenomenon, and resolve it into misconception, or some strength of prejudice in the objector. Men are strangely disposed to indulge a prejudice in sentiment, when they find it attested by tradition, or acknowledged by writers of credit and reputation ; and hence not only the rise, but the confirmation also, of many vulgar errors. In Chambers's dictionary, the truth of this phenomenon is not defended, but only supposed, in order to annex to it, the best solution given by the advocates for the fact ; and this solution a very different one from the above-mentioned. See *Virgula*.

‘ A forked branch, says the article, in form of
 ‘ a Y, cut off a hazle tree---the person who bears
 ‘ it, walking very slowly over the places, where he
 ‘ suspects mines or springs may be, the effluvia
 ‘ exaling from the metals, or vapour from the
 ‘ water, impregnating the wood, makes it dip or
 ‘ incline, which is the sign of a discovery.

‘ Some dispute the matter of fact, and deny it
 ‘ to be possible ; others, convinced with the great
 ‘ number of experiments, alledg'd in its behalf,
 ‘ look

‘ look out for the natural causes thereof. The
 ‘ corpuscles, say these authors, rising from the
 ‘ springs or minerals, entering the rod, deter-
 ‘ mine it to bow down, in order to render it paral-
 ‘ lel to the vertical lines, which the effluvia de-
 ‘ scribe in their rise.’

‘ In effect, the mineral or watry particles are
 ‘ supposed to be emitted by means of the subter-
 ‘ raneous heat, or of the fermentations in the en-
 ‘ trails of the earth: now the *virgula*, being of a
 ‘ light porous wood, gives an easy passage to those
 ‘ particles, which withal are very fine and subtle;
 ‘ the effluvia then driven forwards by those that
 ‘ follow them, and oppressed at the same time by
 ‘ the atmosphere incumbent on them, are forced
 ‘ to enter the little interstices between the fibres
 ‘ of the wood, and by that effort they oblige it
 ‘ to incline or dip down perpendicularly, to be-
 ‘ come parallel with the little columns which those
 ‘ vapours form in their rise.’

Before we proceed to make remarks upon this
 solution, let us observe, that the article as we find
 it here, does by no means stand confirmed by the
 authority of the compiler; for the number of ex-
 periments, or any number of them, is neither ex-
 hibited in proof, nor ascertained upon testimony,
 only *alleged*, by the advocates of the fact. And
 in their attempts towards a solution, ‘ the corpus-
 cles, say these authors, rising,’ &c. this is still their
 own

own solution, and no ascertainment of the fact.— And in the following paragraph; ‘ In effect, says the dictionary writer, the mineral or watry particles are supposed to be emitted, &c.’ Here he does no more than represent to us the hypothesis of persons who patronise the fact (the mineral or watry particles are *supposed*, says he, to be emitted) and leaves the matter there upon the solution of those gentlemen, without establishing it by any other scheme or solution of himself or others. For,

A dictionary writer is not obliged to be a controversialist any farther than he is supported by well established and acknowledged truths — To combat every dubious opinion relating to science were to write a library rather than a dictionary; and therefore a reader cannot expect to enter into all the minutiae of science from a dictionary, any more than he can expect to enter into the force and genius of a language from a dictionary of words and single phrases. It is the business however of a dictionary to take notice of all technical terms whatever, whether grounded upon true or false philosophy, and to give such an historical account or explication of them as is most consistent with the matter they allude to or contain. This is the case with respect to the *virgula divina*, the relation of which, as well as the solution, is plainly given in the opinion only of its abettors.

Let us now examine this opinion. ‘ The corpuscles

pufcles rifing from the fprings and minerals,' &c. Here it is not unreaſonable to preſume, that the particles of theſe effluvia may be inceſſantly emitted (as they are from many phyſical bodies) without any conſiderable or even diſcernible waſte, and yet be of no effect to alter the motion of a ſolid body by means of their extreme minutenefs, tenuity, lightneſs, &c. the volatility of theſe particles ſeeming very inconfiſtent with that weight and efficacy neceſſary to produce the fact alledged. Now the *virgula*, ſays the ſolution, being of a light porous wood, gives an eaſy paſſage to thoſe particles which withal are very fine and ſubtle — fine and ſubtle indeed they muſt be in a very great degree, to enter the pores of the wood, and muſt do this in a vaſt quantity (fine as they are ſuppoſed to be) in order to add to its ſpecific gravity ſo, as to oblige it to incline or dip down towards a paralleliſm with the aſcending column of vapour. If theſe particles are ſubtle enough to penetrate the wood, and of weight enough from their abundance to make it ſink, why are they not, being mineral particles, the objects of ſenſation? If both their ſubtility penetrates, and the impulse of the ſucceeding effluvia, together with the preſſure of the incumbent atmosphere, forces them into the wood, ſo as viſibly to increaſe the momentum of the rod, why do they not ſtrike the olfactory nerve too? eſpecially, conſidering the temper and quality of theſe vapours as iſſuing from mineral ſubſtances, which are not ſo dry as
the

the natural magnet, &c. but of a more humid nature; and thence most probably capable of affecting the sense.

—— But they are said to be oppressed by the atmosphere incumbent on them, in order to be forced into the interstices of the wood — It is well known that the pressure of the atmosphere operates in all directions, upwards, downwards, and sideways alike; why then does it oblige the rod to incline one way rather than another? why, says the solution, by forcing the effluvia into the interstices of the wood, and by that effort obliging it to incline downward. As how? we must suppose indeed by gravity; for there is no other principle which can dispose it to do so; then those particles, minute as they are, must enter in a prodigious quantity to increase visibly the momentum of the rod — Bagatelles! Suppose they do not enter at all by any impulse from the atmosphere? for that they do so, is contrary to very sound doctrine in physics: every one knows that an atmospherical air is enclosed in all animal and vegetable substances, and presses against the incumbent air of the atmosphere as much as the incumbent air of the atmosphere presses against them, and forms an equilibrium of gravity; and this is the reason why animals and vegetables suffer nothing in their sensation and growth from this external pressure, which otherwise would at once destroy both.

Again,

Again, if the lightness or porosity of the wood dispose it to give reception to these over-bearing particles, why is hazle selected for this purpose more than any other wood, variety of which, both green and dry, may be found more fit for this purpose? Several kinds are more porous and equally pliant, when green and the natural juices in them; and if those which are dry are not upon this account so pliant, yet their interstices are more open, and more susceptible, according to the solution given, of the penetrating effluvia. In short, it appears to be a strained solution, and clogged with difficulties in every sentence.

Here again is another difficulty, and seemingly more forced than the particles themselves; for, these are supposed to be emitted by means of the subterraneous heat, or of the fermentations in the entrails of the earth. What! are they emitted thence with such violence, as visibly to affect the motion and posture of bodies upon the surface? In many places they must penetrate a blue rock, impenetrable to the force of any utensil, only to gunpowder; they must penetrate also a stiff clay, or sandy rock, or schistous earths, or several of these one over another, to the depth of forty or fifty, in many places an hundred and fifty, yards deep. (For the ascent of these effluvia must be direct, as is plainly implied in the solution, in order to oblige the rod to incline or dip down perpendicularly to become parallel with the little columns

lums which those vapours form in their rise.) Sure, this subterraneous heat, or fermentation, must be excessively forcing, a very strong hot bed, to raise these powerful vapours through all this opposition. The truth is, the effect is far too great for the subterraneous heat to produce in its operation upon bodies so near the surface; for were the effect so strong as is here represented, all animals and vegetables would feel a very uneasy account of it; and if vegetables received from the influence of it such a visible change of property, animal bodies must much more so, by imbibing, absorbing, and every way receiving the influx of these mineral vapours.

Farther, admitting both the phenomenon and the conclusion, viz. as indicative of a coal-mine below it, why is not this method pursued, and always without exception, in places contiguous to coal-mines?---so easy and compendious a method would save much expence in boring. The reason indeed why it is not pursued is, because it is of no use. It has been found (as men of good credit have attested) of no use in variety of trials in the north of England over places where there is coal, and under which there is not, the stubborn twig will not bend to the exhalations, though issuing from a bed of coal seven or eight foot thick, with another bed of coal half that thickness above it---The subterraneous heat, perhaps, is not so strong there as in the south of England! A ridiculous reason

reason this most certainly; but 'tis in all respects equally plausible with the philosophy alledged for the deflexion of the rod.

It cannot be denied that effluvia may operate with a powerful influence upon bodies within the sphere of their activity, as magnetical and electrical effluvia (supposing that these powers are exhibited by effluvia only, and not modifications of air or æther, or by instantaneous impulses of these) still the power of these effluvia depend upon particular circumstances, as, the interposition of bodies, the distance of the object, the intestine agitation, or rather a projectile power, of the parts of the emitting body, and the texture and quality of the effluvium itself: some or most of these circumstances may operate together, in their proper dispositions, to produce the effect; but let the particles themselves be ever so numerous and insinuating, and the body they issue from ever so protrusive, they cannot operate upon inanimate bodies on the surface, so grossly as the solution represents them to do, through an incumbent mountain of hard rock and solid clay --- it is impossible. Effluvia, capable of working this gross effect, may be impelled, like exhalations, through the fissures and crevices of the earth; but then they would not ascend in perpendicular columns, as the solution supposes, but operate (if they operated at all) in horizontal directions: and even then, suppose them assisted by the general powers of Nature, as by the
subter-

subterraneous heat propelling them to the surface, &c. they must then operate according to the same laws of motion with these powers, viz. weaker or stronger, in proportion to the square of their distance from the impelling body; but this they do not, according to the solution; for instead of the rod being impelled upwards by the ascending effluvia, which it ought to do according to Sir Isaac Newton's third general law of motion, it descends, and declines, as forced into this posture by the incumbent atmosphere --- which, alas, is forced with equal violence into the solution.

If it be objected in behalf of the penetrating power, vigour, &c. of effluvia, that the variations of the magnetic needle are in respect of their cause similar to this, and that the polar magnetic power of attraction is owing, materially, to the polar effluvia. I doubt the truth of this material cause will not be readily granted; the attraction itself is visible, but the effluvia pretended is only an occult quality, depending a great deal upon idea and supposition --- they may be as penetrating, as subtle, and active, as Mr. Boyle supposes, but they cannot have that moliminous and gross effect upon bodies which the solution of the rod supposes them to have. However, let what will be the material cause of the variation of the needle, it is certain there is an efficient cause, and we shall come much nearer the point, if we reject these effluvia as ineffective, and resolve these variations as Dr.

Halley

Halley and other writers have done, by causes which operate in due degrees of strength and efficacy; as the vicinity of mountains and continents, or, the supposition of a nucleus of earth inclosed all around by a superficial shell of a competent thickness. These, 'tis true, are but presumptive causes, and are only alledged as such, but they are adequate to the effect which they are brought to account for; which the supposition of effluvia in the case of the *virgula divinatoria* is not, nor likewise in the case of the variations of the needle, when properly examined; and this is all we are concerned for.

Such a long confutation of this phenomenon and its cause, must appear little more than futility to a learned reader; and it would not have been insisted on, had the opinion not been espoused by persons of good understanding and distinguished judgement in other things; some of whom have it in their power to promote useful and public-spirited undertakings, and might, perhaps, adopt an inclination too to promote them, were the prejudices and objections they have against these undertakings (except in the article of favourite passions) removed; doubtless there are many such gentlemen, all of whom cannot avoid prejudices in subjects which they have not examined: prepossession and objection is common with the world; but nothing is more common in an age of refinement and enquiry than for men, whose prejudices

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and objections are removed, to think and judge better.

It might not be amiss here by way of digression (did it not lead too far from the subject before us, though alluding to the solution just examined) to enquire into the reality of a positive subterraneous heat in the earth; * the greater probability of a body of water in its central parts than fire; the action of the sun, as the prime agent of nature upon the earth; and the degree of this action, considering the comparative magnitudes of the sun and earth (that is, as a diameter of ten inches to a diameter of a sixth part of an inch) as probably capable of answering all the purposes of a subterraneous fire—that changes in the quality of the atmosphere, in respect of heat and cold, elasticity, and rarefaction, occasion many alterations in nature; that all degrees of heat are but comparative in their several subjects, from the intensity of it in the orb of the sun, to the absence of it in any part of the planet Saturn -- for that there is nothing in an absolute state of rest in the whole system of nature—When a phenomenon is resolved into a cause which is merely presumptive and hypothetical, especially when the operation of this cause is not equal to the effect, it may contribute in some cases to render the phenomenon itself suspected, and never fails to render the solution absurd.

* See Dr. Stukeley upon the causes of earthquakes, in *Phil. Trans.* No. 495. p. 641. *passim*, against this notion.

furd: But when a phœnomenon is resolved into efficient and adequate causes, acting according to the general laws of matter and motion, it claims the regard of every philosophical mind; and though the pertinency of the cause assigned may be found doubtful, yet the regularity of its operation, as agreeing with the order of nature, is very plausible, because easy and consistent — consistent with that train of physical causes and effects, in respect of which the actions and operations of nature are found to be so remarkably uniform, and the constitution and arrangement of it in all its parts so well adapted and beautiful.

§ 3. Another objection formed against the probability of success in an attempt to find a mine of coal is, the want of a particular species of herb growing upon the place, or in the neighbourhood of it; which is in the genus of mint, a spurious kind of it; which is supposed to grow no where but in places where those mines are. This notion, when formed into an objection, is so weak and insignificant, that, like many other little vulgar prepossessions and repugnancies of sentiment, it does not deserve other than the reader's inattention and contempt. It is amply confuted by this single consideration, viz. the distance of a possible mine below it from the deepest fibres of its root, were even the root abundantly deeper than it is; and thence the absolute impossibility (except in the case of a fine fancied effluvia!) of the mine extending the influence

fluence of its quality as high as the very surface in the production of the herb. The same answer is adequate to every remark of herbs or plants produced upon the surface by the supposed means of a coal-mine lying at any considerable depth below them.

§. 4. Another objection against the probability of success in these attempts is taken from the disposition of the earth's surface, commonly called *the run of the country*, and affects particular places; such are those which lie between chalk hills, which situation, say they, is not likely to contain any mines or veins of coal, on account of the chalk hills on each side, notwithstanding these hills are at the distance of some miles from each other.

The distance of these hills from each other (admitting that no coals lie at any fathomable depth under them) appears to destroy the very foundation of this objection. For the general depth of coals is inconsiderable, in comparison of the distance between these hills --- the length of from four or five to ten miles, and even more, being alledged as an objectionable distance: Some mines are but forty yards deep, others less, and some of the deepest in England not much exceeding an hundred and sixty fathom. Now whether we suppose the formation of mines to be owing to the action of the sun, to sediments of a peculiar quality succeeding the deluge, to digestions in the bowels of
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the earth from contiguous strata, gleeing fluids, exhalations, &c. in any or all these cases the distance of the chalky hills is such as could not operate either in the prevention or production of coal mines. For, nothing can be supposed communicated from the inside, that is, the internal mass, of these hills to this purpose, they having fewer cavities or crannies than most, if not any, other calcareous earths; and again on the outside, whatever is conveyed from it by its surface from rains goes off upon the surface below in rivulets; or, if it is sucked up by the earth in the vale, it goes little farther than the bottom of the hills, the vale being soon saturated by its own rains—'twere absurd to imagine that any drains from hills can affect mines at such a distance from them, and at such a depth from the surface. Besides, clays in general which are comprehended under the generical name of marl, are found not only in the neighbourhood, but contiguous to, and mixed with, chalky earth: Thus 'Cowston marl is brownish, 'and mixed with chalk—Clay marl of a blue or 'reddish colour, resembled potter's clay, is sometimes found intermixed with calcareous stone. 'These are two of the several sorts of clays, which 'are met with, or may be met with, in digging for 'coal in Great-Britain or other countries.' † If the vicinity of chalk then, or of chalky earth, were incompatible with coal, most probably it

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would

† See Mr. Morand's late treatise upon coal-mines.

would not be found in mixture with those clays, which are met with in digging for coal in Great-Britain and other countries : And in regard to calcinable stone, the earth abounds with it in many parts of the north where there are many coal-mines, and likewise in several parts of the south where there appear to be pregnant marks of those mines.

And here, as an appendage to this section, it may be proper to take notice, that the existence of coal-mines upon the downs in Wilts and Dorset, so full of chalk and calcareous earth, is a point given up by the inhabitants, &c. from the apparent inconsistency or incompatibility of chalk and coal. It is remarkable, that many of these downs want water to a considerable depth, as appears by the sheep-wells dug in some of them, which are deep enough to be at the bottom (where there springs plenty of water) upon a level with the surface of the neighbouring bourns. Now as the downs are, many of them, (probably all of them, which are of more than ordinary eminence) so void of water, it would be a point gained in the conduct of this reply to know, what the ground is, in which those springs issue, and the exact depth of them. This intelligence was requested by the author, as a few other articles were, but he was disappointed in all of them; the answers being slight and unsatisfactory, and most probably framed upon very slender examination. If this ground
could

could be found in several places the same with the surface of the bourns below, and different from the surface or from the general strata above, this would be a confirmation of the conjecture made upon the formation of these downs, viz. That the matter of them goes no deeper than the level of the bourns below, and that they may be only so many masses of sediment, and lax strata, left there at the general formation of the earth's surface.* However, whether this is really the case or not, there are in the bourns many beds of clay, generally gravel, much of which is of a flinty kind; and a flinty stone, which is used in building; and 'tis not improbable (which however is but the author's own conjecture) that there are beds of sand likewise. Add to this, that one species of chalk, or creta, is a fine calcareous stone, and as capable of calcination as other species of them, which are found one or other in abundance in the environs of most coal-mines. Considering then that the soil in the bourns is, in general, not inconsistent with this fossil, no one can assuredly say that it is not there, and (considering the great depth of some coal in

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* One plain instance of this appears from *Phil. Trans.* No. 483. p. 458. in the case of Windsor Loam.

Another instance is in the hills dispersed between the coal works about Chew-Magna, in Somerset. The summit is stony arable, then a lime-stone, then marl, then yellowish earth; "all this lies above the red soil, which is generally the surface of the vallies where the coal is found." *Phil. Trans.* No. 391. p. 395. And it is remarkable, that these beds of stone and marl in the hills lie all horizontal; whereas the coal and its surrounding strata in the vallies lie very oblique.

Cumberland and the environs of Newcastle) even not at a fathomable depth. If in those low situations abundance of water should be found in the ground it can be no objection to the existence of, and is none to the possibility of working, coal there, there being a prodigious quantity of water in some of the mines about Newcastle, as will be shewn in the sequel. — A much better conjecture might be formed of the bourns, upon intelligence of the several strata of the earth there, but as this is not known to the author, therefore he must wave that pretence here.

§ 5. Another objection is a local one, and urged only upon presumption, viz. That there are no coal-mines southwards of Mendip in Somerset, for that there is a general chain of hills from the coal-mines in the north through all the counties directly southward, which chain or ridge terminates at or near Mendip.

It is very doubtful whether this chain of mountain is uniform — persons of good credit have attested in favour of long intermissions of it in the middle counties, and that coal-mines are found not only in the places of these intermissions, but in the lower grounds at considerable distances from these hills. Besides, there are large ridges of hills in Dorset, Devon, and Cornwall, which run in several directions, some of which, in respect of their barrenness and outward appearance, are as promising

sing of the treasure as many of those in the north which really hold it. In short, the general disposition of hill and dale for more than 200, near 300 miles in length, is no indication at all—it cannot be, of a fossil which is to be met with from the very surface itself to a great many different degrees of depth, and some of the thickest strata of it lodging no deeper than fifty fathom. But this falls in with the next general article of this treatise, and might with propriety be referred to the ensuing chapter, which treats of the probable marks of a coal-mine; but as it has been formed into an objection, it is therefore here considered in that light, and is in the nature of the reply no improper preliminary to the subject of the next chapter.

C H A P. IV.

Description of the Strata in Coal-Mines.

IN order to proceed in this enquiry with propriety, and have the whole subject before us, it will be proper to take a view of the strata or materials found in digging for coal in the several parts of England, where these mines are. ---- These then in descending from the surface to the mine are as follow :

§ 1. L A N C A S H I R E,

---- Environs of Wigan, where are many coal-mines; a description of the earth there in *general*.

‘ The surface is of an earth commonly whitish, lying on a flaky stone, which covers a hard rock, under which is a metallic stone, very compact, and of a deep blue. Afterwards appears a new bed of compact stone, though soft; and at intervals under this stone is found a mass, which is a coppery pyrites in filaments. *

A par-

* The quotations in this treatise, mark'd as such, and unreferred to the Author, are taken from a modern and very curious performance, ‘ *The Art of working Coal-Mines,*’ by Mr. Morand, a physician in France, whose descriptions are very nice and circumstantial, and where his intelligence is authentic, appears singularly worth credit; and where it is not so (as it certainly is not in relation to the plenty of coal about Durham) the compiler is not in any respect blameable, but the correspondent can scarcely be treated with too severe censure. — A work so interesting to the

A *particular* description of the strata lying over a certain mine within a mile of Wigan, and nearly eighty yards deep.

‘ From the surface to the rock its thickness is from three to eight yards. The rock is two feet thick, and lies on a metallic stone of a deep blue, and forty-six yards thick. Underneath is common coal, the vein of which is five feet thick, and thirty yards under this is placed the Kennel coal, the thickness of which is one yard and two inches. This coal is called *Ampelites*, and is found in several parts of England, but the finest comes from Lancashire and Cheshire. It is susceptible of a very beautiful polish, and is of such a contexture, that a number of toys are made out of it, as snuff-boxes, &c. &c.

Dr. Leigh, in his natural history of this county observes, that the strata there are, first a bed of marl, then free-stone, then iron-stone, then coal, then some other strata, then coal again.

NORTHUM.

the public as that of pointing out the history, explaining the art of working, or investigating the marks of, coal-mines, cannot be attended with too faithful intelligence. The Author of this is very sensible what an obscure subject he has undertaken, and is obliged to derive his intelligence from all the sources he can find, though some of these appear to be not very satisfactory. In matters of fact any fraud or falshood whatever imposed upon the public is abominable, and even injurious in a subject of consequence; and therefore a relater is doing no more than strict duty, though pointing out the very defects of his own intelligence.

NORTHUMBERLAND.

‘ At Widrington near Berwick they have four fathom clay, then a seam of coal about six inches thick, not worth working, then a white free-stone, then a hard stone, which they call a whin, then two fathom of clay, then a white soft stone, and under that a vein of coal three feet nine inches thick.’

SCOTLAND.

‘ The strata of earths and minerals at the following places in Scotland agree very near, viz. at Tranent, in East Lothian in Scotland; at Baldoe in the parish of Campsy; and at Maidstone near Falkirk. --- They have, as the ground rises or falls, one, two, or three fathom of clay; then eleven fathom of slate or *coal-clives*; one fathom of lime-stone, under that two fathom of slate, earth, and stone; and then coal.

‘ At Baldoe, all along for some miles eastward thence, on the sides of the hills, are *crops* of coal and lime-stone.’ *Phil. Transf.* No. 391. p. 395.

NEAR DURHAM.

‘ Several mines a few miles wide of the road from Newcastle to this city. In general from the surface to the depth of six, eight or ten fathom at most,

most, clay, sand, or gravel is cut through, but most commonly clay : thence to the depth of twenty-five fathom is pale blue rock, which is cut up with mattocks.

The first seam of coal is called the five quarter, in quality hard, and burns to white ashes, the next is the main coal about ten fathom below the five quarter, the best in quality, in general from five to six foot thick, and in some collieries near Newcastle 'tis eight foot thick. The next seam is the marlin coal, about ten fathom below the main coal, in quality better than the five quarter, and inferior to the main coal, and not quite so thick as the main coal. Another called the hutton seam lies eight, ten, or sometimes twelve fathom below the marlin, its quality good, about five foot thick. These are all the seams known in this neighbourhood, though many more may lie lower down. The coal in this country lies at different depths, in different places, within a few miles of each other. There is no iron stone in these collieries.

STAFFORDSHIRE.

West of Dudley in this county : ' Yellowish
' clay immediately under the vegetable earth four
' feet thick ; bluish clay, more or less hard, twelve
' or thirteen fathom ; greystone of a fine grain four
' feet thick ; light coloured clay three or four fa-
' thom ;

‘ thom ; hard grey coloured rock twelve fathom ;
 ‘ blue compact clay five feet ; four different strata
 ‘ of coal, in all twelve feet thick ; below this are
 ‘ found four or five thin beds of iron stone, at dif-
 ‘ ferent intervals, to the depth of about thirteen
 ‘ feet ; then coal again six feet thick ; and ano-
 ‘ ther sort of it two feet.’

NEAR LITCHFIELD.

‘ Brick-kiln clay four feet ; rotten stone two
 ‘ yards ; a flaky light coloured marl six yards ;
 ‘ thin coal, good for burning, four feet, nearly ;
 ‘ black *bat*, six yards ; then coal again, one foot ;
 ‘ next, at different intervals, at small distances
 ‘ from each other, and in thin strata, several beds
 ‘ of rock and clunch, and of this latter one bed is
 ‘ seven yards thick ; these all run down to the
 ‘ depth of ten fathom from the last coal and then
 ‘ comes the main coal, or principal mass, consisting
 ‘ of different strata, to the depth of four yards and
 ‘ three quarters ; then rubbish, or bat, half a yard ;
 ‘ then four yards and a half of coal of different
 ‘ kinds, thickness, &c. This mines covers ano-
 ‘ ther by the same gradation, beginning by iron
 ‘ stone, next light earth, then good coal of three
 ‘ quarters of a yard.’

SOMERSETSHIRE.

Chew-magna Sutton near Stow. ‘ Coal is ge-
 ‘ nerally

' nerally dug in vallies or low grounds : The sur-
 ' face in these parts is mostly a red soil, which
 ' under the first or second spit degenerates into
 ' malm or loam, and often yields a rock of red-
 ' dish free-stone, till you come to four, five, and
 ' many times to twelve or fourteen fathom depth,
 ' when by degrees it changeth to a grey, then to a
 ' dark or blackish rock, which they call the coal
 ' clives: (the plural of clift or cliff, signifying a
 ' rock of any coarse texture.) These clives vary
 ' much in hardness, in some places being little har-
 ' der than malm or loam, in others so hard that
 ' they are forced to split them with gunpowder; so
 ' likewise in colour, the top inclining to red or
 ' grey, but the nearer to coal the blacker they
 ' grow, and wheresoever they meet with them,
 ' they are sure to find coal under them : This is
 ' called the stinking vein. About five fathom
 ' and half under this, seldom more than seven fathom,
 ' lies another vein, which from certain lumps of
 ' stone mix'd with it like a caput mortuum, not
 ' inflammable, called Catshead, they call the Catf-
 ' head vein. About the same depth under this a-
 ' gain lies the three coal vein, so called because it
 ' is divided into three different coals; between the
 ' first and second coal is a stone of a foot, in some
 ' places two feet thick; but the middle and third
 ' coal seem placed loose on each other, without any
 ' separation of a different matter. The next vein
 ' lies about the like depth under the other, the
 ' cliff between them being hard, and subject to
 ' water;

‘ water ; this is denominated the peaw vein, be-
 ‘ cause the coal is figured with eyes resembling a
 ‘ peacock’s tail, gilt with gold, which bird in this
 ‘ country dialect is called a peaw. The cliff also
 ‘ over this vein is variegated with cockle-shells
 ‘ and fern-branches.

‘ Under this again, between five and six fathom,
 ‘ lies the smith’s coal, about a yard thick ; and
 ‘ near the same depth under that again, the shelly
 ‘ vein ; and under that a vein of ten inches thick,
 ‘ which being little valued, has not been wrought
 ‘ to any purpose.

‘ Four miles south east from this at Faringdon
 ‘ they are said to have the same veins, which agree
 ‘ in all parts with those afore-mentioned. And in
 ‘ another place the same veins seem to retain their
 ‘ regular course. Also to the north east of this
 ‘ situation, at Stanton-drew, about a mile distant,
 ‘ the same veins are found again.

‘ In the same parish of Stanton-drew, they have
 ‘ another coal-work, which has several veins, but as
 ‘ yet only three are thought worth working. They
 ‘ are in all respects different from the former. The
 ‘ uppermost about three feet thick, small lime-
 ‘ coal. The next is about three fathom under it,
 ‘ about two feet and a half thick, fit for culinary
 ‘ uses: the undermost is about the like depth under
 ‘ the former, only ten inches thick, but good hard
 ‘ coal.

‘ At

‘ At Clutton, about two miles from these latter,
 ‘ in the same drift, these last veins appear again.

‘ At Burnet, Queen-Charlton, and Brisleton,
 ‘ they have four veins. The surface is red land,
 ‘ generally to the depth of four or five fathom.
 ‘ The uppermost vein is from three to six feet
 ‘ thick at Brisleton, but less at Charlton and Bur-
 ‘ net. The next, call’d Pot-vein, is six fathom
 ‘ under the former, eighteen inches thick; all
 ‘ hard coal. Thirdly, the Trench-vein, seven fa-
 ‘ thom under the other, which is from two feet
 ‘ and half to three feet thick, all solid coal.--
 ‘ Fourthly, Rock-vein, always distinguished by a
 ‘ rock of paving stone, called Penant, lying over
 ‘ it, which rock is sometimes twenty feet thick, or
 ‘ more. It is computed seven fathom under the
 ‘ former.

‘ Almost all these have the same strata of earth,
 ‘ malm, and rock; and every vein hath its clives
 ‘ over them, and all agree in the oblique situation
 ‘ of the veins.’ *Phil. Transf.* No. 360. p. 968.

STONY-EASTON, *in the same County.*

‘ Within five miles northward of this place,
 ‘ there are six distinct coal-works. The chiefest
 ‘ observables I met within them are,

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‘ First,

‘ First, the Branched Clift, which usually lies
 ‘ over the coal, and is all wrought with the repre-
 ‘ sentations of sundry sorts of herbs.

‘ Secondly, a Clift, all interwoven with arbo-
 ‘ rescent marchasites, which commonly lies over
 ‘ the former, and is called by our colliers the
 ‘ Thorny Clift.

‘ Fourthly, we may here take notice, that on
 ‘ one of these works, was found about two or
 ‘ three hundred weight of very good lead ore,
 ‘ growing to a vein of coal, the ore being ting’d
 ‘ somewhat yellow by the sulphur. We look upon
 ‘ this as a rarity with us, none ever having been
 ‘ found in a coal-pit before, the sulphurous spirit
 ‘ being there generally too strong for the genera-
 ‘ tion of that metal.’ *Phil. Trans.* No. 1. p. 6.

S H R O P S H I R E.

‘ In Brosely, Bently, Pitchford, and other pla-
 ‘ ces adjacent, there lies over most of the coal-
 ‘ pits or mines, a stratum or layer of a blackish
 ‘ rock or stone of some thickness, which is po-
 ‘ rous, and contains in it great quantities of bitu-
 ‘ minous matter.’ *Ibid.*

N. B. The

N. B. The author was disappointed of the intelligence he requested, by epistolary correspondence out of this county. In a treatise of this nature, a writer cannot be furnished with too many materials, nor receive too much intelligence of the strata of the earth in those countries where coal-mines are, in order to compare the accounts of these, severally, with those parts of the country, where these mines have not yet been found : for out of the very numerous examples, capable of being produced, by record and living testimony, of the disposition of these strata, some parts might be discovered, in all probability, (which contain mines either unsought or undiscovered) agreeing nearly with some of those thus described ; and the marks of agreement or similarity, visible upon this comparison, by pits, quarries, hills, waters, &c. may prove a powerful means of encouraging the search. The present attempt, indeed, will be found so defective, that it cannot be expected to answer the purpose of so interesting and benevolent a design ; yet, mean as it is, it may contribute to awaken the world to the subject, and excite the inclinations of those who love their country, and can better describe it, to undertake the generous enquiry. Should it be successful enough to accomplish this aim, its principal intention will be answered ; for it has neither ambition to aspire at, nor hope to expect, a more fortunate issue. In the pursuit then of this attempt, let us reconsider the strata of the coal-mines already described, and draw them up into

§ 2. *A more methodical and compendious View.*

LANCASHIRE, TOWN of WIGAN.

	YARDS.
1. Whitish earth lying on a flaky stone, from	3 to 8
2. Hard rock	2-3ds.
3. Metallic stone, very compact, of a deep blue	46
4. Common coal	1 2-3ds.
5. Blue compact soft stone, and at intervals a coppery pyrites	30
6. Kennel coal	1 1-18th
Total depth	87

NORTHUMBERLAND, at WIDRINGTON
near BERWICK.

1. Clay, the kind not mentioned,	8
2. A thin seam of coal	0 1-6th.
3. White free-stone, depth not mentioned,	
4. Hard stone, called a whin-stone, depth not men- tioned, but probably considerable,	
5. Clay	4
6. White soft stone, depth not mentioned,	
7. Coal	1 1-4th

SCOTLAND, EAST-LOTHIAN,

TRANENT, BALDOE, MAIDSTONE, FALKIRK.

1. Clay, the kind not mentioned,	4
2. Slate, or coal-clives,	22
3. Limestone	2
4. Slate, earth, and stone	4
5. Coal, thickness not mentioned,	
Total depth	32

Between

Between DURHAM and NEWCASTLE, at a particular Place
full of COAL-MINES.

	YARDS.
1. Clay, sand, or gravel, mostly clay,	12, 16, or 20
2. Pale blue rock, just penetrable to the utensils,	50
3. Coarse coal, very capable of use, called five quarter coal	1 1-4th.
4. Very hard rock	20
5. Main coal	2
6. Very hard rock	20
7. Marlin coal	1 1-half.
8. Very hard rock	20
9. Hutton coal	1 2-3ds.
Total depth	116

STAFFORDSHIRE, a little to the West of DUDLEY.

	YARDS.
1. Yellowish clay immediately under the vege- table earth	1 1-3d.
2. Bluish clay	1 2-3ds.
3. A bluish clay, more compact and firm,	8
4. Ditto of the same colour, softer,	3
5. Grey stone, fine grained,	1 1-3d.
6. Light coloured clay	7
7. Hard grey coloured rock	24
8. Blue compact clay	1 2-3ds.
9. Coal, four different strata together,	4
10. Iron-stone, at different intervals, four or five thin beds,	4 1-3d.
11. Coal	2
12. Ditto, another sort,	0 2-3ds.
Total depth	71

D 3

Near

Near LITCHFIELD.

	YARDS.
1. Brick-kiln clay	1 1-3d.
2. Rotten stone	2
3. Flaky light coloured marl	6
4. Thin coal	1 1-3d.
5. Black bat	6
6. Coal	0 1-3d.
7. Rock and clunch, at different intervals	20
8. In the mass of the 7th article, one bed of clunch alone, 7 yards deep	
9. Main coal, different strata of,	4 3-4ths
10. Rubbish, or bat,	0 1-half
11. Coal, of different kinds	4 1-half
12. Iron stone, light earth, &c. strata in the same gradation, depth unmentioned,	
13. Coal	0 3-4ths
Total depth	<hr/> 42 <hr/>

At BURNET, QUEEN-CHARLTON, and BRISLETON, in
the County of SOMERSET.

1. Red land from the surface	9
2. Stratum, as before, viz. clives,	
3. Coal,	1 1-3d.
4. Clives	12
5. Pot-vein coal	1 1-half
6. Clives	14
7. Trench-vein coal	1
8. Clives	7
9. Rock	7
10. Rock vein coal, thickness unmentioned,	
Total depth, probably,	<hr/> 70 <hr/>

SOMER-

S O M E R S E T S H I R E.

CHEW - MAGNA ; at SUTTON near STOWY.

	YARDS.
1. Red soil	0 1-half
2. Malm or loam; in some places a reddish free-stone entirely	8, 10, or 24
3. Changing from a grey gradually to a blackish rock, called coal clives; depth not mentioned, but probably considerable,	
4. Coal, the stinking vein, thickness not mentioned.	
5. Coal clives	12
6. Cathead vein	
7. Coal clives	12
8. Three coal vein	
9. Clift or clives, variegated with cockle-shells and branches of fern	12
10. Peaw vein	
11. Coal clives	11
12. Smith's coal	1
13. Clift or clives	10
14. Shelly vein, thickness unmentioned,	
15. Another vein of coal	0 1 3d

Total depth, probably, 90

STONY-EASTON in this County, several MINES.

1. Thorny clift, of arborescent marcasites.
2. Branched clift, representations of herbs.
3. Coal.

SHROPSHIRE ; in BROSELY, BENTLY, PITCHFORD, &c.

Stratum of blackish rock or stone in most of the pits, and immediately under this is coal, neither depth nor thickness mentioned.

C H A P. IV.

Materials most usually met with in the mines above-mentioned, &c.

§ 1. **N**OW in the next place let us observe which of these strata is most usually met with in the coal-mines.

Clay above and hard stone below are more frequent than any other; they are so not only in the short specimen here offered, but in other instances of mines within the author's own observation in the north, and within the course of his intelligence in Somerset. But the particular succession of the strata in any more than those referred to he has not been able to procure information of. The quantity then and quality of these two strata are to be considered.

In regard to *Clay*, it is remarkable that where it is of any considerable thickness, it is generally not of a light or lax consistency, but more compact and solid, fat and unctuous to the touch, and lying in beds from two to eight yards thick; and in many places in the counties of Durham and Somerset, considerably more. There is also another clay of a different quality, which often occurs in descriptions of the earths, in the environs of coal-mines in England, viz. Malm or Loam, Terra-miscella, an earth partly clayey, and partly sandy; that is, partaking

partaking of clay and sand in an equal proportion. This sort is in one of the specimens of the Somersetshire mines produced here; and there is observable likewise among the mines in another part of the same county, the blue and fat clay, in no small quantity. Clunch is often met with in these mines, and commonly borders upon a blue colour; it is 'a fine blue clay, as described by a writer upon mineral bodies, *Argila plastica particulis subtilioribus*, which is used in some parts of England for making tiles, which are very hard.' A blue and compact clay is also a considerable stratum in the Staffordshire mine. There are clays of a brownish and deeper colour, and likewise a whitish clay, (the cretaceous properly so called) and a yellowish found in coal-mines, but not by far so frequent in general as the blue; and some of these are but rare in this situation. As the species of clay generally form the upper stratum of the earth in these mines, let us annex to this account of them an observation of Dr. Lister, in *Phil. Trans.* speaking of the usefulness of a soil—or mineral-map, he plans examples of his scheme out of Yorkshire, among the western mountains, where lie 'sand-stone, coal, iron-stone, 'lead-ore, sand, clay, &c. Now, says he, if it 'were noted how far this is extended, and the limits of each soil appear'd upon a map, something 'more might be comprehended from the whole, 'and from every part, than I can possibly foresee; 'which would make such a labour very well worth the

‘ the pains. For I am of the opinion, such upper
 ‘ soils, if natural, infallibly produce such under
 ‘ minerals, and for the most part in such order.”

§ 2. Next in notice is *Stone*, the quantity of which does much exceed that of clay, and the quality also in respect of its variety. As to the quantity, it constitutes, for the most part, the principal stratum in our descent to the mines; the stratum of blackish rock in Salop, of the clives in Somerset, the rock near Litchfield, the grey-colour'd rock in Staffordshire, the pale blue rock in many places between Durham and Newcastle, slate or coal clives in Scotland, hard stone (probably) at Widrington, and the metallic stone at Wigan in Lancashire, do all evince the truth of this remark. It lies immediately over the coal in abundance of places, and being so thick, hard, and frequently impenetrable, cannot but have some kind of efficiency in the formation of the mine. Certain it is, that some kind of stones possess one of the principal qualities of mine, sulphur; and are found contiguous to it, viz. The marcasite and pyrita; the marcasite particularly, which abounds in the English mines in general, and contains some antimony, as does also the Newcastle coal. They are said to form entire strata in some places, and in others detached lumps, or nodules. In several mines near Stony-Easton in Somerset, a clift interwoven with arboresecent marcasites is found the second bed above the coal, and lies immediately upon the branched clift, so called, being

ing wrought with a representation of vegetables. In regard to pyritæ, which are inflammable metallic substances as well as the other, they are found in strata of stone, in clay, and in earth lying over the mines of several metals; but are not frequent in coal-mines, though they are very pregnant with sulphur; 'Scotch coal has very little
' of the pyrites in it, being mostly made up of
' coal-bitumen; and therefore it burns and con-
' fumes quickly, and leaves a white cinder. New-
' castle coal burns slowly; and the Sunderland sea-
' coal so slowly, that it is said, by proverb, to make
' three fires; this has much pyrites mixed with
' it, and burns to a heavy reddish cinder, which is
' iron by the magnet. Ph. Tr. n. 157. p. 512.

Free-stone is found lying over the coal in Newcastle and Staffordshire, but not in that of Somerset, tho' the coal in Somersetshire, and Gloucestershire, is of the same species with that, and in some of the mines of Staffordshire the top of the strata of coal is formed of free-stone, and abundance of free-stone is in several parts of the north in the vicinity of coal-mines; in some places different kinds of it both in point of consistency and colour both reddish and light coloured, hard and soft, being all found in the same quarry: It composes a stratum of considerable depth in some of the mines of Somerset. The particles of it are flinty and sandy, but the mass is neither combustible nor calcinable. It separates freely, and is cut into
shape

shape in any direction, whence most probably it derives its name. But more usual than this, is

The schistous stone and slaty coal, called shale in Derbyshire; which is of different consistency according to its depth in the earth, 'and is more or less hard and compact according as the neighbouring beds are more or less solid.' It is ranked here as a stone with slaty coal, because it is of a moderately hard and firm consistence in general, and not penetrable to water, and capable of very legible impressions from a pencil.

* One species of these is earthy and soft, and found in very large beds in the parts of the kingdom that contain coal. This schistus, exposed to the air, first runs into leaves; afterwards it dissolves by means of the salts, with which it is generally impregnated.—There is a second species of schistus, which is very earthy, of a jet colour, smooth and glistening on its surface; sometimes its texture is firm, sometimes friable and loose, so as to be easily divided into plates. It is heavy and of a middling consistence, yet water does not penetrate it, and being scraped, it yields a blackish powder. It is too soft for burning with steel, but in burning it assumes the colour of a pale and whitish red, resembling exactly, except that it is leafy, a piece of dry pipe clay. It is found in coal-pits and always lying on the coal, particularly in Somersetshire and Yorkshire. In its separations it shews,
between

between the plates it is formed of, some very distinct and very agreeable impressions; in the softer and more friable schistuses, as in those of Somersetshire, impressions of fern, reeds, and gramineous plants are most commonly met with: but in the harder and not so easily divisible into leaves, as those of Yorkshire and Wales, the impressions are very rare, forming a kind of network, shells, &c. This species is found lying over coal, in several parts of Europe and England, and always abounds with impressions; and all the schistuses that are met with in coal-mines of any part of Europe are only varieties of this, every species of schistus found in those mines is called slate-coal, and may serve for a marking stone. They find them of different colours, but that which is properly called the schistus carbonarius, or slate-coal, is always fat.' A white slate frequently turns up in strata in sinking coal-pits in the North, and some of the hard schistous and slaty earths are observable in shelving declivities, projecting from the bed in which they lie, in several parts of England.

In regard to *Lime-stone*; abundance of it is found and used both in those counties where there are supposed to be no coal-mines, and in those where there really are; and more than this, there is much variety of it in both. A rubly lime-stone rock in one short ridge of mountain, a hard and flaky one in another but a very few miles from it, is near
Durham

Durham, and the coal-pits are in the adjacent valley: The former of these calcined, is inferior both in point of cement and duration to the latter, and the sea rock lime much preferable to both. There are several kinds in those parts, which are more different in the raw stone, than after calcination. In Devon and Dorset is found exceeding good limestone, and particularly in the center of Devon, and near Dartmouth, but no coal-mines have yet been found in those counties; but in the parts of Scotland above referred to, and in many parts of Northumberland, there is very great plenty of both lime and coal; but the varieties of the former are such, that it is difficult thence to form a conjecture with any tolerable precision concerning the existence of the latter. At Baldoe in the county of East Lothian, the extremity, or head of the vein, called crop, has intervals of lime-stone, from crop to crop, for a considerable way along the hills.

The *Coal Clives*, so called, or *Clift*, so often mentioned here, is so frequent in the mines of Somerset and Scotland, that in the former of these it is esteemed a direct indication of coal, and the very next step to it—but of this in its proper place. There is no small variety of it in respect of consistence and colour, being light coloured, reddish, grey, or black; and being also of a various firmness, from the softness of malm nearly to a stubborn and even impenetrable hardness; it is also either massy, coarse or fine grained, or flaty. In short,

short, it is all those lapideous strata, which are not uniform to any particular depth, but vary in their descent, penetrated by the miners in sinking; rubbly, slaty, of a harder or softer, coarser or finer texture, &c. and comprehends some of the species of bat, so called, in the mines of Staffordshire. The miners call rubbish of earth, stone, slate, &c. by the general name of Bat; thus the rubbish of brick we call in common language, brick-bat.

Next comes the *Hard Blue Rock*, some of it just penetrable to the utensils of the workmen, and other parts of it absolutely impenetrable, except to explosions. This rock is in larger or smaller masses, and in thicker or thinner beds, as it happens. It seems to be of a remarkable thickness and impenetrability in the mines between Durham and Newcastle, and partakes of the last property equally with the hardest clives in Somerset. In the former of these situations it lies next the coal both above and below it, and from its dryness and the exceeding closeness of its texture appears neither to imbibe any kind of quality from the mine, nor the mine from it. There are likewise large quarries of stone in that part of the North of a lightish colour, of very solid masses, which are found both larger and finer in texture the lower the workman goes, which is a very common circumstance in many quarries of stone, not only in coal countries but in others. The deep hard grey coloured rock near Dudley, bearing within a fathom of the
coal,

coal, has without doubt something of the same tendency in respect of the indication or formation of the coal with the pale blue rock near Newcastle, Durham, Wigan, &c.

‘ There is likewise among the stony materials found in coal-mines in England, a very hard rock, called rock flint stone; rocks of stone for paving, and sorts of pebbles that are found in entire beds, and not in detach’d masses as the ordinary pebbles. They call them whin-stone; in some parts of Derbyshire they are called chert, or whern,’ and there they are found in lime-stone, and not always disposed in strata.

Iron-stone is also found in many coal-mines; several strata of it, and in much variety, being met with above and below the coal near Litchfield and Dudley; and probably the metallic stone at Wigan partakes of the nature of it; some of it being in the coal-mines of Lancashire. This kind of stone is not only in the coal countries, but in many where coals have not yet been discovered: a very deep bed of iron-stone lies at Stoke-hill near Exeter, some of which the author has seen dug up there at the depth of forty yards, with small lamina of coal adhering to it, about as thick as a half-crown; this species of it is not unlike one of the kinds of iron-stone dug out of the mines near Dudley, as appears by the description of the latter from Mr. Morand.

§ 3. Next

§ 3. Next us let consider *sand* and *gravel*; these being laxer strata than ordinary generally lie at no great depth, unless it happens to be a sand-rock, and this is dug through at considerable depths in some mines in the north. There are many red-sand rocks in different parts of the country, and very deep ones in the neighbourhood of some coal-mines in the county of Durham; one mountainous ridge there about a mile in length begins with a rock sand-bed several fathom deep, coarse grained, and runs into a free-stone in some places; and for the most part into a coarse lime-stone, being rubly gravel at the top. The rock-sand cellar at Nottingham is well known. There is a large hill of sandy rock near Yeovil in Somerset, and also several smaller hills of a coarse grained sand, like that in Durham, and of the same colour, nearly, only the large hill above-mentioned somewhat lighter; but the colour of this mineral, tho' there be a variety of it, is of no signification in comparison of its component parts and structure. The sand and free-stone in the mountainous ridge above referred to in the north have both of them many small pebbles visibly cemented in the mass, together with mica of glittering particles, but it is doubtful whether even any difference in the configuration and cohesion of its parts proceeds from its vicinity to coal-mines, though it is often found in them. Sand, says Dr. Lister, Ph. Trans. No. 164. p. 740. has the greatest hardness, and conse-

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quently

quently durableness and unalterable quality of any other mineral in nature—especially mountain sand, as appears from the hardness, and dryness of its grains, which therefore, probably, keeps its natural and original magnitude. And let us add, that the sand in coal-mines is in several pits of the same texture and quality.

§ 4. In regard to *gravel* it is generally a superficial stratum, dry and rubly on the hills, and wet and flinty in the vallies. The mass of it is so much mixed, that it can scarcely be denominated one species of matter; consisting of small particles of flint, sand, pebble, &c. and its larger parts being lime-stone, flint-stone, &c. cementing and cohering together according to the solidity of the mass, which when taken up to the surface for use, is the more firm and compact in proportion to the absence of marly or earthy parts; the gravel dug out of watry pits forms, for the most part, a harder consistence than that which lies more exposed and dry, as the earthy parts are washed off, and the pure stone left behind. Thus it is in the gravelly channels of brooks running along a high road, the soft and muddy parts of which channels are washed away by the stream, while the stony parts remain, and are disposed by the agitation of the water into a close consistency and connexion with each other. This mixed mass generally lies immediately under the surface, and is so varied,
that

that it is no other than a composition of different specific materials ; not properly ranked under any particular kind of stratum, but reducible to the genus of all that rubble, which passes among the miners under the generical name of bat.

§ 5. It has appear'd from repeated observations made from time to time in mines, and from the case of several of those which are quoted here, that the strata of the earth do not lie at a depth proportion'd to their several degrees of hardness, nor proportioned to their different specific gravities ; the softer stratum being often found below the harder, and the heavier above the lighter. " Supposing the mass of the terraqueous globe to consist of ten thousand different materials, all originally, while in a soft and fluid state, tending towards the center ; it must mechanically, and almost necessarily follow, by the continual revolution of the crude mass from west to east, like the winding up of a jack, or rolling up the leaves of a paper book, that every one of these strata, tho' they each reach the center, must, in some place or other, appear to the day ; in which case there needs no specific gravitation to cause the lightest to be uppermost, &c. for every one in its turn, in some place of the globe or other, will be uppermost ; and were it practicable to sink to the center of the earth, all the strata, that are, would be found in every part, and, according to the poet, *Ponderibus librata suis*. Add to this, that in all

the places within my knowledge, the observation of Dr. Stukely has held good, that the precipices of all hills are to the westward, whereas the ascent to the east is more gradual." Phil. Trans. No. 391. P. 395.

CHAP.

C H A P. V.

Strata indicative of, and not inconsistent with, Coal.

THE substance of this chapter is, in effect, an inference from the former two, which, had they been more copious and more full of materials, would have afforded a much better choice of premises for a conclusion ; the point in proof would have been much more attainable ; and the investigation of physical marks, indicating the vicinity or presence of a coal-mine, much more satisfactory to every reader, who may have zeal enough to encourage, or ability to undertake the *execution* of such a public-spirited design as to engage in the search of it.

§ 1. Let us begin with those indications of a coal-mine which are acknowledged and declared to be such by the miners themselves in their respective works.

1. Coal clives in Somerset : ‘ the top of these is reddish or grey, and becomes of a deep black as it approaches the coal ; when the colliers find this black colour, they are sure of soon finding the coal.’

2. ‘ Bluish clay, compact and firm, called clunch by those who work at the mines near Dud-

ley: it is to them a certain indication of the vicinity of coal; and they find on it the impressions of plants'

3. ' The clift, called in some parts of England branched clift, marked with phytotopolithes, stalks or leaves of plants.'

4. ' The clift over the peaw vein in Somersetshire is variegated with cockle-shells and fern-branches; which are always an indication of the vein.' Ph. Tr. No. 360. p. 968.

5. Hard blue rock of any considerable thickness in some of the mines near Newcastle.

6. In some of the mines of that part of the country a sand-rock two or three fathom thick is a mark of coarse coal.

There are, no doubt, in the various parts of the country where coal-mines are, many other strata contiguous to the coal, which are judg'd by the frequency of their appearance in that situation to be tokens of approaching coal: At the same time certain it is, that what tops the mine in one county does not do so in another; so it is with Staffordshire and Somerset, in the former the mines being covered with a kind of free-stone, and in the latter with brown or black clives; to which may be added, as instances of variety, the pale blue rock in the county of Durham, the clunch near Litchfield,

field, &c. &c. places, where the immediate indicative token can be known no otherwise by the mines than from the frequent appearance of it in that situation: This now being so different in different counties, cannot in the work of mining be consider'd as a general indication in one county because it is so in another, though that other be adjacent to it, and a coal country; provided it lies some competent distance from the former. much less can it be considered as such in places, where attempts of finding coal have not been at all, or but unsuccessfully, made. The occurrence of such strata in any place whatever is an argument that it is not repugnant to all kinds of coal there, nor perhaps to any; however it cannot be an indication of much consequence, unless it were *cæteris paribus* in this mine with those where it is an indication.

As this is the case therefore, suppose an attempt made to find one of these mines, of any kind, in places or parts of the country where none has been yet discovered; and suppose one of these indicating strata to occur at any competent or likely depth, the probability of conjecture from the appearance of it there would depend upon the materials met with in sinking, and the similarity of those materials to such as are met with in the mines where this very stratum is an avowed indication. For it may prove no indication at all, if those materials, which occur in the descent to it, are quite different from

the materials in those pits where it is such. Hence therefore the necessity, as is once before hinted, of a description of a large number of pits for the sake of a comparison: an example of this is the covering of the mines in Northumberland and Staffordshire, which is very different from the covering in Somerset and Gloucestershire; and yet the coal in Northumberland and Somerset are in specie the same. It is not known in what manner coal-mines are formed, nor by what material agents, whether by communication from surrounding bodies, or confinement by them, or by the action of heat or moisture upon the substance originally deposited there, and matured by time into the consistence in which we find it—these are some of the arcana of philosophy, the *ne plus ultra* of human investigation, which is as much a stranger to the internal essence or primary qualities of body, as to that of spirit; and therefore cannot argue a priori from either; all our knowledge is from experience, and this grounded upon observation of only the secondary qualities of bodies, which is the boundary of human knowledge, and the foundation of all our reasoning about them; but the primary qualities being absolutely unknown, therefore the connexion between primary and secondary (the most essential connexion which physical bodies possess) is also entirely undiscoverable. Locke on Hum. Und. book iv. chap. 3.

To go on then upon the system of observation and experience, and upon this foundation to

§ 2. Other

§ 2. Other probable, tho' not avowed, marks of coal.

One species of schistous earth, ' commonly called shale in Derbyshire, is formed of many beds from the clay or surface of the earth to a considerable depth. The bed which is near the clay is always softer than that which lies deeper, and the colliers assure, that it is more or less hard, more or less compact, according as the neighbouring beds are more or less solid, more or less soft; and its texture varies, as its consistence, in proportion to the depth at which it is plac'd; so that the same bed in the point it approaches the surface of the earth acquires sometimes a very leafy texture, but, if followed, as it sinks deeper in the earth, it is observed that it becomes harder, and assumes the form of a plate of metal——The substance varies according to the upper or lower bed; for if the upper be lime-stone, it becomes drier, more hard, more brittle, and moulders in the air, but if it be upon a bed of bind, which is more massive and more coriaceous, it is more earthy and soft. It is found in very large beds in the parts of the kingdom that contain coal, and generally over the coal.'

Another species of schistus, which is found in coal-pits, and always lying on the coal, particularly in Somersetshire and Yorkshire, is described at pag. 60. This is probably the same as the ' Gublin

lin bat, a black fissile substance' very near the coal at Dudley. 'It is divided by beds and leaves as coal and slate. It is hard in some parts, and more soft in others. This bed may be considered as an iron-mine, in which the bituminous leafy earth abounds, which will be applicable to the substances' lying immediately over the coal.

Clunch, bordering upon blue, and compact, like that clay described at article 2. as one of the marks of indication acknowledged by the miners. This lies immediately upon the first bed of coal at Dudley, as the gublin bat or one very like it does over the second.

These are all the materials which the author has been able to collect as either *avowed* or *probable* indications of coal, and lying in the earth at a considerable depth, either immediately upon the mine or extremely near it. Let us then pass to

§ 3. More visible marks, viz. such as appear upon the surface, or not far under it.

Coal is generally dug in vallies or low grounds in the parts about Chew-Magna. "The surface of these parts is mostly a red soil, which under the first or second spit degenerates into marl or loam." Phil. Tr. 360. 968. There is likewise a reddish soil, which soon terminates in loam, in some of the collieries

collieries on this side of Newcastle; in the neighbourhood of which are found many strata of sand and lime-stone.

Clay of a blue colour, and compact and firm in substance, more or less unctuous to the touch, and lying in beds of any considerable depth. This is called clunch by the miners in some places, and clum by those in others, who call any stiff and heavy clay also by the same name. This lies in several beds, successively, from the surface, in the mine near Dudley; over and near several of the mines in Somerset, and also in the north of England. If this clay has a very thick stratum beginning from the surface, or near it, (as it has in all the three places just mentioned) it is a pregnant mark of coal below—were there no other example of it than what has been found in the mine at Dudley, this alone were sufficient to ascertain the indication.

Clay of a deep brown colour, very close and heavy, with a mixture of sandy parts in it, is very frequent in collieries either over the mines or near them; but is not reputed so probable a mark as the other.

To this last may be added distinct beds of clay and sand near the surface, of more or less depth as it happens, the sand being of a coarse grain and red or reddish hue. These are very common in some
of

of the collieries near Newcastle, which sometimes open with deep clay, sometimes with sand, and in some pits with both in succession.

Some miners have given out that a layer of coal of any kind appearing at day light, that is upon the surface, is a good sign of a mine somewhere near it: And the observation may be very just in regard of the substance of good coal, which is a compound inflammable mineral; for wherever a stratum with these qualities are found, it is a certain proof that the earth around it is not destructive of these qualities; and at a considerable depth in the earth the sulphureous parts, wrapt in the stone, may be less liable to waste and decay, than near the surface where it is more exposed to the changes of air, and successions of wet and drought. See pag. 90.

An attention is due also to springs of a vitriolic hue, which tinges the channels, ditches, &c. where they run. These are often-times met with in the brooks between Durham and Newcastle, where they are supposed to issue from beds, or to wash beds, of inflammable mineral, from whence they derive their tincture. The water that runs from some collieries near Newcastle is very vitriolic, giving as deep a tincture, with galls, as Scarborough Spaw.

In the neighbourhood of the coal-mines between
tween

tween Newcastle and Durham are large quarries of rock under a gravelly surface, which in some places cut out very massy, and fit for building, or flaky and fit for pavements; there are also others of limestone, coarse and rubly, with small pieces of spar here and there in it; and likewise some of slaty stone, which calcines better, and makes a more durable cement. The veins of coal in some or most of the mines near Mendip are wrapt in a very black and very thin earth; but this earth is not to be considered as necessarily connected with the coal wherever it is found, because in the neighbourhood of those places, where the veins are thus wrapt, a deep bed of earth of the same substance has been cut through at a competent depth, and no coal found at the bottom.

§ 4. Strata by observation, not inconsistent with coal.

All kinds of clay, or marl, which naturalists in England have reduced to six in number—coarse free-stone—coarse lime-stone—and slaty stone—very hard blue rock—beds of coarse sand—iron-stone, which though not in some of the collieries near Newcastle, yet abounds in the mines at Dudley, and is found in some near Litchfield—red earth at the surface, and the same to a considerable depth—lead-ore, of which too or three hundred weight, exceeding good in its kind, was found formed on a vein of coal near Stony-Easton
above

above-mentioned ; and much of it in the northern counties among, and some at Mendip on the hills near, the coal-mines there.

The water in the common rivulets and brooks among the coal-mines near Newcastle is of a brownish hue, and in many places discolours the pebbles much in the gravelly channel in which it runs ---some springs there issue out of rocky places, and afford a very clear and light water ; other springs are strongly petrified ; others are gentle or strong chalybeates.

The consistency or inconsistency of particular kinds of earth, stone, clay, &c. with the situation of coal-mines, is a point in which abundance of mistakes are committed by people who live at a distance from coal-countries ; and who frequently apprehend that to be a mark of no mine, which is found to be very consistent with it in some parts of the world, where mines are. Such mistakes as these would at once be obviated by a general enquiry all over the coal-countries, (partly in person, and partly by epistolary correspondence) and in consequence thereof, by a distinct scheme of the strata of these mines in general ; and where the difference between mine and mine in the same or different counties is inconsiderable, to treat them as such in the scheme, and join them together in the same class.

A scheme of this kind would be extremely more feasible than meteorological schemes to assist observers in the calculation of the weather.—This last, depending upon almost an endless variety of accidents and casualties, is not capable of being reduced to any sure and establish'd system; but the former depending upon marks of probability absolutely fix'd and settled, must of course suggest a more regular and methodical conjecture. The industrious enquirer, far from being lost in the clouds, would in all his researches find himself upon a sure and useful footing; for the discoveries, which he has made, will be a perpetual foundation for the application of most useful conjectures in places, where the success of these conjectures would prove a public blessing; and the short and humble attempts of the kind, like this before us, would be absorb'd and lost in the overflowing intelligence, as well as the extensive utility, of such an universal and charitable plan.

CHAP.

C H A P. VII.

Local Application of the indicating Marks.

AS there is no better illustration of any rule or set of rules, than drawing them out into practice; so there is no better way of explaining the foregoing articles of indication than by applying them to any part of the country likely, or presumed likely, to afford marks of the discovery—those parts especially, where no discovery of these mines have yet been made.

The environs of Exeter and Sherborne are very suitable objects of this examination; first upon account of the external probable marks of coal in both places, at least, such as have been and frequently are deem'd so; and next on account of the attempts which have been actually made in those places; the issue of which attempts, particularly in the latter of these two, still remains doubtful: therefore the environs of Sherborne, which are better known to the author than those of Exeter, will not seem impertinently singled out for application.

Here is abundance of lime-stone in several places, some of it of a rubly rock, other of it more massy and compact: that which is of the rubly kind is to all appearance the same in the rock as

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at a certain quarry nine or ten miles south east from Newcastle, but the former calcines into a much better cement; in both places the rock is divided from the surface by a rubly gravel, but with no mixture of flint in it.

Hard blue rock is found upon West-hill impenetrable to any utensils; and which in breaking up to mend the turnpike road the workmen are obliged to blow up with gunpowder. The texture of it is very close, and in the blasted fragments it appears to be of a granulated consistency; probably not unlike the rock in some of the mines in Somerset, which at the upper part is grey, and becomes of a deep black as it approaches the coal: When the colliers there perceive this black colour, they are sure of soon finding the coal. The pale blue rock in the mines between Durham and Newcastle, impenetrable except to gunpowder, is to appearance, some of it at least, of the same nature as this; but in the hill here referred to this stone lies in detach'd strata, some higher and some lower, and even these strata, interrupted by a coarse earth; whereas this stone lies, as has been described, in deep massy rocks in the north.—Though it is doubtful whether it is constantly thus, the author having been informed while in those parts, that this hard rock in some pits is not thick, but soon cut through. Be this as it may, where there is any considerable quantity of it, whether in one uniform mass, or in detached parts, it is an article

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worth regard in the examination of the country before us; and it will appear particularly so, when we consider the quantity of

Blue compact clay found in the side of the same hill. This clay is dug out of a pit at the side of the road about six feet from the surface (but probably much deeper) and for a considerable length: The same clay is also found near the top of the hill some fathoms in thickness, (as the quarrymen there give out) lying under two small strata from the surface, one of coarse sand, and the other of a coarse slate; and there are also several other places where this same clay appears in small detached parts on the sides of the common road. This clay is fat to the touch, and bakes by the sun extremely hard; it appears to be nearly the same as the clunch described at pag. 57, *quod vide*. Travellers have often represented it the same as the beds of clay among the coal-mines at Mendip. Near this clay-pit an attempt was made many years ago by sinking to find coal, when at the depth of about sixty feet, the miners found a foul kind of coal, which did indeed burn, but emitted a very stinking smell; upon finding this coal it was supposed there was no better coal in the place, and the mine was quit-
ted, and soon after filled up. This now appears to have been a very hasty conclusion; for in coal-mines it is generally the case, that the worst or basest stratum of it lies uppermost; and had these adventurers descended, considerably lower, it is not improbable but that considering the strata above
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and below and all round them, they might have hit upon a coal much more worth their notice. At Bishop Sutton in Chew Magna the first vein is called a stinking vein: Its coal is hard, but of a sulphureous smell, yet good for mechanical uses.—It were pity but the coal dug up in this adventure had been compared with that, and the strata of earth, &c. also down to it; then some rational conclusion might have been formed of the probability of success.

The clifts, which are dug up in this hill, are some of them found marked with impressions of a vitriolic colour, and in a round or winding form, as if occasioned by some fluid gleeing between the interstices of the clift. If coal be then, as without all doubt it is, ‘a concretion of bituminous matter, separated from the bowels of the earth, variously combined with earthy, saline, pyritous, and metallic substances,’ then the veins of water in the earth, which always derive either a hue or tincture from the bodies which they wash, must indicate the existence of those bodies of which they share the tincture. And though this tincture may not proceed from any beds of coal, either of the foul or useful kind, yet it is impregnated with the qualities belonging to those fossils of which the coal is concreted; and when it is consider’d that a foul kind of coal has already been found there, this impression upon the clift appears to be by no means unworthy of regard.

A few miles to the west of this town is a large extent of reddish vegetable earth ; which in some places is said to reach several feet deep ; there is likewise a large sand rock through which runs the turnpike road, on the sides of which the rock appears to be five or six fathom deep, and probably in several parts of it, if not generally, deeper than the road ; also near Yeovil is a bed of fine marl about three fathom deep in the ground, and of a considerable extent ; were then the strata of earth and stone observable in wells and quarries, well known in these parts, and that to the depth of fifteen or twenty fathom, and these strata compared with those here described, or with any other where coal-mines are, then a competent conjecture might be formed of finding coal ; for the superficial marks here are consistent with those in coal countries, and if the subterraneous marks are not inconsistent, 'twere ground enough to justify the reasonableness of an attempt, without either the imputation of caprice, or the merit of ridicule upon the projector.

To these may be added the curious quarry stone near Yeovil, strongly marked with impressions of plants : for this, though not of the marcasite kind, being neither metalline nor inflammable, yet is in appearance very like some of the branched clift, which is an indication of coal, and called Plate, in the environs of Newcastle.—All the figures in the figured stones which we see are supposed

supposed not to be petrifications of real plants, proceeding from the sulphureous quality of the enclosing stone, but are found to be, many of them, superficial delineations, owing both their matter and form to their natural situation; 'The figurations in the snow are to this purpose; the delicate landscapes, which are frequently in Somerset found depicted on stones, resembling whole groves of trees, mountains, and vallies; the fern-branch clift, so deep as the coal-mines there; some resembling the leaves of sorrel, and several strange herbs, which perhaps the whole vegetable kingdom cannot parallel:' Dr. Lister. — In coal-mines (says another author) where the sulphurs are strong, are found great lumps of very bright marcasites, and great varieties of herbs depicted; and yet some of these herbs, as well as the trees, mountains, &c. above-mentioned, are supposed not to have ever had their antitype in the vegetable world; so minute a representation at so great a depth appearing inconsistent with the magnitude of their parallels upon the surface.

These observations may be greatly confirmed by a due intelligence of the strata of earth, stone, sand, clay, &c. which lie below, and might prove these parts to be similar to some others, where this fossil is dug up in plenty: Notwithstanding which, a caution will not be improperly suggested here to the reader, viz. that he be not too hasty in his application of the remarks made in the course of this

treatise to any particular place, lest if a trial should be made, and without success, the conclusion should be carried too far, that is, to a greater depth and more extensive than the phenomena of the trial will warrant, as was likely the case in the trial above referred to at West-hill: Therefore in order to render the attempt accurate and effectual, the application of indicating marks cannot be too circumstantial. To this purpose it were an object of public spirit well becoming the character of a person of fortune and penetration, to make the tour of all the coal countries in England, to form a collection of them according to their strata, and publish this collection—the very great variety of mines, ranged under their proper classes of similarity in respect of their several strata, professed marks of indication, &c. would suggest copious grounds of comparison to gentlemen, who live in a country, where these mines through the increasing scarcity of wood are greatly wanted, and who would sink in the likeliest places to find them.

In the parish of Holneft the attempt made to find coal was unsuccessful, for no coal was found; and the particular motives of inducement in the adventurer, who was a man of fortune, are absolutely unknown; tradition itself does not pretend to any notice of them. Let these be as they will certain it is, that the clay and gravel here, of which there is abundance, is of the same kind with such as is plentiful in some coal countries; the clay being of several sorts, much of it sandy, and forming
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a kind of loam, some of it brownish, and much of it of a blue colour, lying in thick beds, very close heavy and compact; the gravel being full of flint and hard pebble.

At Pinford-hill near Milborne-Port, there is at the foot of the hill a clay of a bluish hue, but not so deep a blue as that is in the other places referred to, but neither the texture nor depth of this clay is known to the author; these circumstances however must be in the notice of several people, who remember the last attempt made there for coal; and cannot be incapable of a just application of these remarks to the place of this attempt. This hill is contiguous to a short ridge of mountain, which appears to be gravel all along under the vegetable earth, and under that a rock of limestone of a rubly, or of a flaky texture, which probably reaches to a considerable depth: Perhaps under this very rock may lie the clay above mentioned, the hill appearing to have been the effect of an accumulation of matter at its formation, having a very gentle and gradual declivity to the east, and a very steep one to the west. See p. 67.

Near Chew Magna in Somerset, in searching for coal mines they endeavour, or used to endeavour to find the crop,* which of course led the searcher

* The crop among some mines, and the basseting among others, is a term signifying the appearance of the mine in its natural bed upon the surface of the earth.

searcher to the mine ; to this it is very probable that the first discovery of such mines in those parts has been owing. It is remarkable also, that this mineral breaks out upon the surface in several parts of Scotland, where coals are plentiful ; so plentiful indeed, that they are not worth the trouble of working them out of the pits through want of a market for the sale of them. At Aukenclauch, six miles from Kylesith, is a bed of coal eighteen feet thick. This is also the case (that is the appearance of crop) with several mines in the environs of Durham, but not in any such degree as it is represented to be by Mr. Morand ; who says, that there this fossil is so near the surface of the earth, that the wheels of carriages lay it open, and the inhabitants of this part have a sufficiency from what is constantly exposed for their own use, that of their neighbours, and likewise to make it a valuable branch of their income. The contrary of this is well known to all the inhabitants in those parts, where some pits are worked for land-sale, that is, home consumption, and others for the sea trade only, and both these at a great depth and a great expence. 'Tis pity that so curious an author upon so interesting a subject should be betrayed by any kind of false intelligence whatever—in matters of fact no candid enquirer can easily be mistaken, unless he is abused by misrepresentation: For the truth of this fact is applicable to some places where by accident the coals appear at the surface, as the five quarter coal does at Lumley in
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several places by the river side near Durham, where a miller and some of the neighbours draw it out from the bank upon sledges, and receive enough for their use this way only. And the cavity in some of these places is so large, that the gentlemen and inhabitants there with much propriety assure you, that they go into good coal-mines without ever having descended into a pit.

Now at West-hill near Sherborne, several pieces of coal have been taken up out of a ditch, which was indeed a very foul coal, but it was real coal, very inflammable and sulphureous, and burnt to ashes. It had no apparent connexion with any strata of the same kind in the ground, though such was found in a pit of inconsiderable depth sunk in quest of coal near the same place, of the nature and consumption of which coal notice has already been taken. These casual lumps of coal therefore, though they fall not under the article of crop so called and here defined, yet they are a plain indication, that so far as this compound inflammable mineral derives its formation from contiguous strata, the contiguous bodies of clay, earth, &c. found there had something in their nature and quality very consistent with the production of such a mineral. See p. 76.

Mundick, which is only another name for the pyrites, is often met with in these parts, and not many miles off very plentiful. Dr. Lister asserts, that

that no mineral or ore whatever is sulphureous but as it is wholly or in part a pyrites, which both in gross and vapour is actually of its own accord fir'd, as coal-mines are. And some of it is so pregnant with sulphur, that fire separates it from tin, and evaporates it into smoke. To this pyritous or sulphureous quality residing in coal are owing the strong tints, variegated like the iris, of a golden colour, such as is the peaw vein, or peacock's tail vein, in Somerset, and the glossy hues of coal in other parts, like those of a pigeon's neck. But this is rather foreign to our purpose, the subject of which is not the nature and quality of this mineral, but the characters of its indication only.

It may here be objected, that there can be no certainty of success in an undertaking founded at best upon conjectures; that the formation of fossils, depending upon a probable concurrence of natural causes subterraneous and far out of sight, is one of the arcana of natural philosophy; that the expense of sinking a competent depth is too much to hazard upon so precarious an issue; and that the safest and best method of investigation is to be determined by ocular demonstration of the crop at the extremity of the mine. *Ans.* Where the crop does not appear, and probable marks occur, the value and importance of the discovery is well worth the undertaking; and the very instance of probability will exempt the adventurer from censure, though his honest attempts should fail of their wished

wished success—for the public are more interested in the discovery than himself, and would upon the view of the first successful attempt, be singularly zealous of making more discoveries (since where one mine of this kind is found, doubtless there might exist many more) while the first adventurer, beside the honour, the generosity, the charity of the first discovery, would share a prime interest in the value. Were success certain, how many adventurers would start up? and then neither the same thanks, nor the same gains were due to the projector: while success is but probable (and it cannot be more than so, while grounded only upon rational conjecture) this were ample motive to justify the reasonableness and propriety of the attempt, propriety, I say, because, notwithstanding all the supposed arcana in physics, probability will ever be allowed to proper researches in the article before us. For,

Though the formation of mines cannot in any case be particularly proved *a priori*, and in this sense may continue a secret to mankind till their last general explosion; yet the proofs of their existence and situation *a posteriori*, that is, from the circumjacent strata of earth, stone, clay, &c. may prove by frequent and numerous examinations so uniform and accurate, as to satisfy the enquiries of every ingenuous adventurer, and render any attainable degree of conviction beyond it superfluous. Degrees of improvement bring every art and science

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to perfection. While the power of electricity appeared to consist in no more than the minute attractions and repulsions of small bodies, who could have imagined that a series of experiments would arise from it, sufficient to found a theory capable of very probably resolving the causes of earthquakes, of diverting by proper directions the force of lightening, and of tracing the most intrinsic properties of the animal and vegetable world? and yet after these amazing applications of the theory there remains still an ample field for farther discoveries: this however was one of the inscrutable parts of philosophy about thirty years ago: as was likewise during a great part of the last century, the horizontal parallax of the earth, and the theories consequent upon it; till, minute as the observation must be (so minute, that an error therein can be little less than the whole parallax) the phenomenon is likely to be ascertained to a great degree of accuracy by the late transit of Venus. —But there ever will remain occult qualities in naturals to the indifferent, the luxurious, the partial, and the lazy examiner; who enjoys by his own warm fire-side the productions of nature, without exerting himself either to discover or to produce the comforts of them to those who are ready to perish in want of them; whose self is the center of all his pleasures and passions—and the circumference too.

CHAP.

Fire and Water in Coal-Mines.

AFTER this account of the utility, investigation, &c. of coal-mines, it may not be amiss to close the whole with some remarks upon the methods of preserving them, when found. The two principal enemies of their operation are, fire and water, which are each of them, if not kept at due distance, destructive both to the workmen and the work.

§ 1. First with regard to fire. In quarrying out so sulphureous a mine as that of coal, no wonder that plenty of inflammable vapour will arise, and in so contracted a cavity, so moist and stagnant an air must of course soon become foul and unwholesome in proportion to the quantity of sulphur wherewith the mine is impregnated; and this adhering to the top and side of the mine, and the longer the more accumulated, it becomes accensible by the flame of a candle. Even without the application of a foreign flame, the sole fermentation of the vapour composed of different inflammable particles, will dispose it to take fire, flash like gunpowder, and wherever it finds a vent, to issue out thence with a violent explosion.

These explosions in coal-mines, happening from fire damp, as they call them, are well known in
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all countries where those mines are, and where they have been worked away into a competent cavity. Out of many instances of these dreadful explosions one, which happened about fifty years ago near Newcastle upon Tyne, was very remarkable: seventy men were all blown out of one pit at once by the violence of the blast, miserably maimed and mangled, some of them at the distance of an hundred yards from the pit's mouth; and a large square piece of timber, called the start, which is the primum mobile of the machinery (about nine or ten yards long, and nine or ten inches thick,) was blown to some considerable distance, and stuck into the side of a hill; where it was permitted for many years after, and probably to this day, to remain as a monument of so memorable an accident. — There were near forty men blasted by the discharge of one pit about two years ago near Chester in the street, Durham; and about a year ago a great many workmen partly killed and partly hurt, in some of the mines near Mendip in Somerset. After an explosion of this kind happens, which bursts with a prodigious report, it is too or three days before the pit is capable of being worked again by reason of the sulphureous stench left in it, which takes up all that time to subside.

Some pits (so dangerous is the situation of the honest labourer) are easily set on fire by the caprice

price of any of the workmen, who chuse to apply a candle to the top or vault of the mine; the flame issuing from which application will spread by degrees to such an extent as to fire the whole pit, unless it is presently after the first accension extinguished by plashing a little water upon it.

Also, if there be any communication between any old pit which is cast off as foul, and a new one which is clean, the air passing through this communication makes a rustling noise, like that of a hollow wind, and the working pit will be foul and accensible to the distance of several yards from it.

Now the one thing needful to prevent all this danger, whether happening by design or by accident, is to contrive a circulation of air in the shaft, that is, a continual succession of fresh air in the caverns of the pit; so that the foul air being by this means driven off, the labourers would pursue their work with more security, and thence satisfaction, and thence also with less expence to the proprietor; the danger of the employment being a very reasonable pretence of enhancing the price of it. The Hessian bellows invented and improved for this purpose many years ago did much execution, but was not adequate to the whole extent of this design. They require a great power to produce a proper effect, and act only by forcing pumps. In remedy of which inconveniences, and to act both by sucking and forcing draughts occasionally, Dr.

Desaguliers

Desaguliers invented an engine, consisting of a triple crank, working three pumps, which both suck and force air by means of three regulators, and are alternately applied to drive air into or draw it from any place assigned—as the damp is specifically lighter than the common air, they may be driven out of the mine, or if heavier, they may be suck'd out, by the operation of this engine, which is so contrived as to be varied for this purpose; and the execution of it is such, that one man may change in one minute the whole air in a cubic space, whose side is eight feet; and a horse do four times the work of one man. Some of the proprietors of mines object against this engine, as both inconvenient and inadequate; but the mode of objection is not known to the author.

Other ventilating machines have been applied to this use, some with a very small degree of success, others with more, but none with a degree of execution adequate to general use. The coal fire furnace, called in the north the fire lamp, has been found of eminent use in many pits near Newcastle, the cavities of which are generally larger than most others, and many fires have undoubtedly been prevented by this contrivance; but it is not used in all the pits there for reasons known, perhaps, only to the proprietors. Certain it is, that fire will not do in all cases, because several sorts of damps extinguish fire; and some fulminate and are dangerous when fire comes near them. This

This contrivance however, exceeding useful as it is, is yet cumbersome, and like the other inventions, operates upon the object with a kind of *violence*, and continues no longer in operation than the fire continues to burn. A better contrivance than this, could an expedient to effect it be discovered, were such as would operate in a more *natural* way, viz. by some change effected in the direction of the wind, such as would always be taking effect, while the wind is blowing; and while not blowing, the fire lamp might supply its use. A thought to this purpose was started lately by Dr. Franklin of Philadelphia, in his experiments and observations on electricity, who applies the daily passage and repassage of fresh air in chimnies to the consideration of such a natural contrivance as is here desired. The quotation is too long for insertion, but the sum of it is this. The rarefaction of the external air by the heat of the sun, and the want of it at night, occasions a difference between the specific gravity of that air by day and the same by night; but the air in the chimney, being of the same middle temperature as the chimney which protects it from the influence of the sun by day and the cold by night, will therefore ascend by night and descend by day, according as the specific gravity of it is changed by the successive rarefactions of the external air. ‘I think, says he, this property might be made of use to miners,’ supposing a chimney erected near the mouth of the pit, and all air excluded from it at the bottom except

what should pass up and down the shaft, by this means a constant change of air would be produced in the passages below, tending to secure the workmen from those damps that incommode them.

This scheme, like several others, is very just as it is curious in theory, but of too weak effect to accomplish its proposal. Nothing however can be devised more consistent with the ordinary operations of nature; for from the different affections of cold and heat result most of the variations in the density, currency, &c. of the air, which is always changing its condition according to the approach and secession of the sun. But the air in subterraneous caverns is stagnant in that confinement, and not liable to these changes; whereas could it be made by any currency of communication to obey these alterations in the external air, then the denser air, whether external or subterraneous, would always be passing through the channel of communication to the place of that which is more rare.

In contrivances for this purpose, a particular misfortune is, that two differently operating machines (provided such were applied to encrease the effect) seem incapable of having their full effect together; and therefore in the very nature of the thing the contrivance must be simple and uniform. A stream of air in windy weather may be derived from the atmosphere capable of serving
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all the uses for which it may here be wanted, were it possible to circumstantiate it in such a manner, that the obliquity of its descent might occasion no diminution of its strength.—Notwithstanding the improvements which have been already made in pneumatics, there are yet in so fine a field of science, many more improvements and discoveries capable of being made. The powers of nature, howsoever prevalent and extensive, are yet liable, in every common and useful degree of them, to particular direction and controul from the powers of art.—But this remark coincides with, and will be illustrated by, the next article.

§ 2. With regard to water. — Almost all coal-pits are more or less troubled with it; and some to such a degree, as to want a drain of more than an hundred hogsheds in a hour. Sometimes a larger bed or reservoir of water has burst in upon the work, and has filled the whole cavity of the pit so as to rise a good many fathom up the shaft, before it gets up to a level with its spring. Friar Goose colliery, near Newcastle upon Tyne, had three engines fixed, which drew up, one with another, two hundred and fifty hogsheds of water in an hour, yet the colliery was drowned notwithstanding all the three engines wrought against it. There are several engines in that part of the country which draw from an hundred and fifty to an hundred and eighty hogsheds in an hour: Mr. Emerson in his description of this engine says, it

will “ deliver three hundred or more hogheads of water in an hour ;” but this is a degree of execution which none of these accomplish, that have been seen by the author, though he has seen many of them in the county of Durham. This is indeed great execution, but it is only proportionable to its occasion, the mines in those parts being extremely troubled with water.

This kind of engine, called the coal-fire engine, is exceeding moliminous and expensive, costing in a part of the country, where the materials are generally cheaper than in other parts of England, from eight hundred to a thousand pounds, and some more. The of reason this enormous expence is owing to the method of its plan and operation ; as it works by a large balance of a prodigious weight suspended upon the wall of the building ; the vibrations of which balance are owing, alternately, to the pressure of a semi-atmosphere upon a circular area of thirty-six or forty inches diameter, and the force of the steam of boiling water in counteraction ; the boiler used for this purpose containing many tons of water, which is constantly recruiting by a pipe of fresh water, while another pipe is discharging the evaporated : It is kept boiling over a very large coal-fire furnace, and must be renewed every three or four years ; the quantity of coals necessary to keep this water boiling is from twenty to thirty bushels every twelve hours.

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Now all this enormous expence and incumbrance might be avoided by suitable improvements in hydraulic machines, which are little more than so many modes of the mechanical powers. For while it is impossible to ascertain what quantity of burden is moveable by any given power or powers, so long 'twill be impossible to ascertain the precise length or boundary of mechanical improvements. These open to the industrious investigator a field of researches more inexhaustible than the most pregnant mines they assist; and may be directed to any method of impulse, as well as heightened to any degree of power: And while the exigencies of society require farther additions of improvement, and these mechanical inventions are so much subjected to the power of art, those gentlemen do not even their duty to their country, whose leisure, fortune, and faculties are in these instances capable of yeilding it service, but directed by selfish inclinations to do it prejudice. The prostitution of themselves to base and sordid gratifications results no better, than in a consumption of those comforts and conveniencies which the industrious of their species are every day striving to support. And who can deny, that the supply of these comforts in all the various branches of their demand, might not have been at this day much more feasible and easy, had the drones, the wasps and flugs of society, dedicated as the bees have done to the use of their community, those abilities, which they have employed in rapine,
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and corrupted by indulgence? The Society for the Improvement of Arts, &c. have done excellent things, by holding out the prize of art to the emulation of the mechanic, the merchant, and the husbandman, &c. artists, whose interest, indeed, has been connected with their ambition: Some of them have not solely patronized the cause, but led the way to improvement, and held out the illustrious copy of imitation, as well as the golden prize of encouragement: This is really the summit of true honour and virtue, and in just character of the noble, the obliging, and the brave! Indeed, the sole patronage of art in the opulent and able, is meritorious of the esteem and gratitude of their country; and has prompted the intention of the inventor in a multitude of curious and useful improvements. A remarkable instance of hydraulic execution, whether prompted by the above-mentioned patronage or not, is the discovery of the late curious chain-pump, celebrated for the ease of its power, the strength of its execution, and the mobility of the machine — It discharges, by the power of two workmen only, one ton in fifty-five seconds; which by computation exceeds the execution of the common coal fire engine little less than one half. The experiment was made on ship-board; but it is reasonable to imagine that on land, where the foundation is more steady, the power might operate with more ease and advantage; in either case, the movement of such a burden is surprising, and, with

with proper application, might execute the same effect in coal-mines, or suggest by a due regard to its machinery a proper contrivance for that execution. There is scope enough for improvement in this walk of genius from Mr. Ferguson, Emerson, &c. writers upon mechanical powers; who have both by calculation and experiment supplied a fund of amusement to the taste, and assistance to the invention, of their readers.

The water-wheel, so called, is of very good service to such mines as are not burdened with a great quantity of water, but they are for the most part only of local application, and not adequate to the occasion of a very large drain, nor of universal use. There are also other methods of drawing off the water, so that the quantity left does not impede the workmen, but are not effectual without much trouble. And the execution of some is so imperfect, that they are rather palliations than cures, saving indeed the existence of the work, but render the work no more than tolerable; whereas one general machine, that shall accomplish great execution with great ease, will answer the full purposes of this convenience in every place whatever. That such a machine is within the reach of art is obvious, because, tho' any conceivable weight cannot be moved by any conceivable power with the same velocity, yet the property of mechanical power is such as to be equal to this design with a suitable disproportion
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of velocity: For the greatest conceivable disproportion between the velocity of the power and burden is demonstrable in theory, and that it is not so in execution will be no wonder, because objects of mathematical idea may be true by intuition of the mind, but very improperly applied to physics or to the senses, and may lead a projector into gross disappointments. Hence it is that many mechanical inventions, which have been just and accurate in projection, have failed in execution. What is gained in *power* is lost in *time*, and puts any the most advantageous machine in a state of equilibrium between the burden and power; the machine itself being only the instrument of accelerating the given force, but not of producing a new one, which had no existence before. A machine then, as an instrument of motion, is possible to be contrived which shall multiply the power impell'd to a surprising degree of acceleration or aggravation, and be capable of actual employment; and provided the strength of the materials, and the conveniency of situation concur, may be applied to the use here mentioned, as well as any other.

In fine, it is not at all improbable that some marks of futility may appear in the course of this composition to a sagacious reader, who possesses more extensive intelligence or greater depth of judgement than the Author. He was not afraid, however, of committing to the eye of the public
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the notice of his own sentiments upon so interesting a subject, being prompted by a motive superior to all the sneers of contempt, or the wild airs of ridicule, viz. A REGARD TO THE WELFARE OF MANKIND: And in pursuit of this motive he knows not how to give a better proof of his integrity, than by dedicating the profits of this publication, if any such arise, to the use of the poor of his parish. — Contented, indeed, at all events, with the discharge of his duty in this exertion of his humble talents and employment of his leisure; but abundantly happy, should the result produce any successful attempt to find these comforts of life, which are the subject of his pen, or some more successful attempt than this to investigate and explain them.

E I N I S.

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